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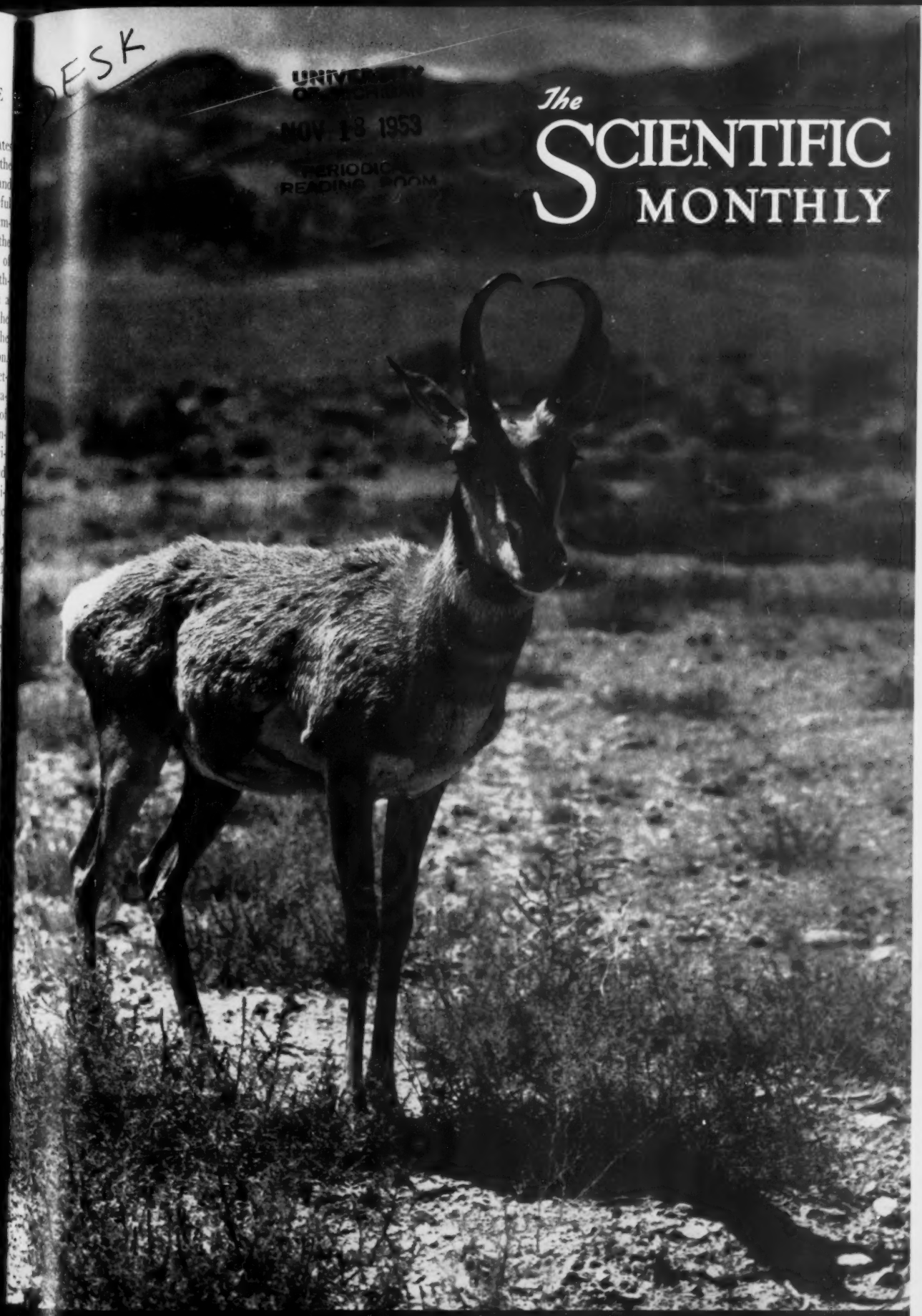
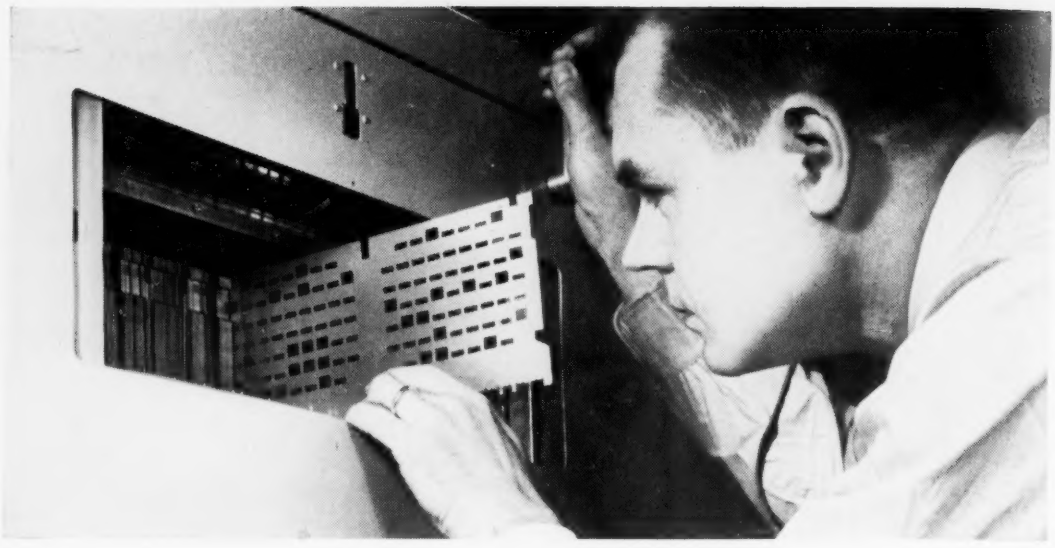
The SCIENTIFIC MONTHLY





Checking perforated metal card in Bell's new "card file." If the first voice-way is in use, a "detour" is swiftly found.

CARDS FOR CONVERSATION

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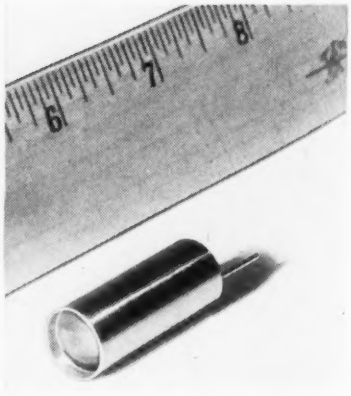

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THE SCIENTIFIC MONTHLY

VOL. LXXVII NOVEMBER 1953 NO. 5

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Established 1872 as *The Popular Science Monthly*; since 1915 an official publication of the American Association for the Advancement of Science.

Publication office, Business Press, Inc., 10 McGovern Ave., Lancaster, Pa. Orders for subscriptions and requests for change of address should be directed to the Circulation Department, A.A.A.S., 1515 Massachusetts Ave., N.W., Washington 5, D. C. Subscriptions: $7.50 per year; single copies 75 cents. Four weeks are required to effect change of address.

Address all correspondence concerning editorial matters and advertising to THE SCIENTIFIC MONTHLY, 1515 Massachusetts Ave., N.W., Washington 5, D. C. The editors are not responsible for loss or injury of manuscripts and photographs while in their possession or in transit; all manuscripts should be accompanied by return postage. The American Association for the Advancement of Science assumes no responsibility for the statements and opinions expressed by contributors.

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Boston, Mass., December 26-31, 1953

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THE SCIENTIFIC MONTHLY

NOVEMBER 1953

A Visit to Barro Colorado Island

WARREN ANDREW and NANCY ANDREW

The authors have worked together on a number of research projects and have published the results jointly. Dr. Andrew is professor of anatomy and director of the department at the Bowman Gray School of Medicine of Wake Forest College. He has done graduate work in the zoological sciences at Brown University and Yale University, and received his Ph.D. from the University of Illinois in 1936. He later received his M.D. from the Baylor University College of Medicine. He has occupied teaching positions at the University of Georgia, Baylor University, Southwestern School of Medicine, and The George Washington University. In 1945–46 he was visiting professor at the University of Montevideo, Uruguay. He is the author of a monograph, a translation from the Spanish of a general cytology by De Robertis, Nowinski, and Saez, and a number of scientific articles. Mrs. Andrew is the former Nancy Valerie Miellmier of Akron, Ohio.

WE had been a long time thinking and talking about the projected visit. Since some forgotten day in the past when a biologist friend had mentioned Barro Colorado we had sensed something of the great attraction which the very name of the place and the knowledge of its biological marvels have for students of the science of living things.

The idea took real substance when Dr. Alexander Wetmore, the Secretary of the Smithsonian Institution, spoke with fine enthusiasm of his own days in Panama, on oft-repeated expeditions.

Barro Colorado is a part of the Canal Zone Biological Area of the Smithsonian Institution, and our request to spend some time on the Island was granted with a minimum of formality. We had read of the richness of the molluscan land fauna and wished to collect specimens of the huge tree snails, both for general and histological study of these forms.

The flight from Miami was pleasant. We had chosen to go by LACSA (Lines Aereas de Costa Rica), and so we found ourselves in a Latin-American atmosphere from the time we boarded the plane. The rather dreary terrain of the southern tip of Florida soon fell behind us, then the long chain of islets to Key West, and soon we were over the beautiful, palm-decked countryside of Cuba. At the airport of Havana we made a brief stop, then were off again, this time soaring into heavy clouds and a driving rain. After what seemed a long time, we sighted the waters again below us. It was not too surprising to us to hear the steward fervently say, "Gracias a Dios," as he pointed to the cape be-

low. We soon recalled that this actually is the name of the jutting headland over which we were flying. Now the green hills of the little country of Costa Rica appeared, and soon, in a lovely valley, the Capital City, San José, with its colorful red-roofed buildings. As we deplaned, we were led by a courteous official through the busy terminus and into a large dining room. Here, instead of a customs examination, we were simply asked, as guests of the Republic of Costa Rica, to choose between beefsteak and chicken for our lunch.

Beyond San José we had wonderful views of the long beaches, of the jungle-covered hills, and the many rivers and streams flowing into the Caribbean. We were impressed by these vast stretches of wild scenery with no signs of habitation nor of any of the works of man for mile after mile.

The works of man, however, became very evident as we soared over the Pacific coast and obtained a fine view of Panama Bay and of the great Canal itself. The Miraflores Locks seemed surprisingly close, and higher up the Canal we could see the Miguel Locks clearly. It is a ride of some fifteen miles from the airport at Tocumen to the Tivoli Hotel in Panama. We were there in time for late dinner and early retiring.

Early next morning we learned that we would have three days in the city and that on Tuesday Dr. James Zetek, the director of the Laboratory, would meet us on the train to Frijoles and the Island. Although we were eager to get on to our real destination, we welcomed the opportunity to learn a little more of Panama City. Especially we wished to visit the famed Gorgas Memorial Institute of Tropical Medicine.

Here we met Dr. Herbert Clark, director of the Institute. His robust physique and hearty manners, as well as his quick intellect, seemed to belong to a man much younger than his seventy-odd years. We knew that he still could put many a younger man to shame in tramping through the rugged jungle country, so often necessitated by the research projects of the Institute. Dr. Clark told us a great deal about the early days of Barro Colorado and the struggle to maintain the ideal of conserving it in its present state, an almost untouched tropical wilderness. He told us also many details of the work of the Gorgas Memorial Institute. It is not nearly as easy as it may sound to effect a program of anti-yellow fever vaccination among scattered communities and family groups of Indians—not even with the aid of the modern helicopter for penetrating the brush—especially when many of the natives may be of another mind.

The laboratories and animal quarters are fascinating places. Sheep graze in the walled-in en sure about the main building, and in the rear large cages with monkeys of several types. Here the big red and black spider monkeys, which h interbred in cages, with good healthy baby m keys resulting. Here are howler monkeys, vici macaques from Asia, and delicate, big-eyed ni monkeys.

The insectary presented us with a novel wa raising mosquitoes. Glass microscope slides cov with a growth of nutritious yeast served as the "m bottles" for the larvae, which eagerly cluster ab them.

It was in the second-floor laboratory of Dr. Al ander Fairchild that we first were shown specim of some of the molluscs from Barro Colorado. T were large and beautiful shells of species which had not encountered.

Two days later, on Tuesday, we were up at da and off on the train for Frijoles. Here for the fi time we met our host, the curator and resid manager of the Barro Colorado Island Laborat Dr. James Zetek, an internationally famous en mologist. He has done fundamental studies on tr ical diseases and is an authority of many ye standing on the insects and molluscs of Pana His work on behalf of establishing and maintain Barro Colorado Island Laboratory has made name familiar to all those who have seen the b logical treasures of this region. Dr. Zetek int duced us to Dr. Dunn, professor of zoology at H erford College, Pennsylvania, and to Mrs. Du Both are herpetologists, particularly well acquain with reptiles and amphibians of tropical Ameri

At Frijoles we boarded a launch to carry us the Island. We had not realized that the route the ships passing through the Canal and Ga Lake brings them so very close to the Island sho but now we saw the buoys and shore lights mark their course.

Barro Colorado Island lies between 9 degree minutes to 9 degrees 11 minutes North latitu and between 79 degrees 49 minutes and 79 degr 53 minutes West longitude. The island is alm in the center of the Isthmus of Panama in the Ca Zone. The damming of the historic Chagres Ri formed the waters of Gatun Lake, and made isla of many hills. Barro Colorado Island is the larg of these. It has a shore line of 42.85 miles and area of 3840 acres. It is approximately 3 miles diameter and has a very irregular coastline. It separated from the mainland at the nearest point about 300 yards of deep water which includes t channel of the Canal.

Barro Colorado Island became a natural reser

on in 1923 by order of Governor Jay J. Morros, nd through the efforts and initiative of Dr. Zetek nd Dr. Barbour. The Institute of Research in ropical America was organized for the develop- ent and management of this reservation. Launch rvice connects the Island with the railroad to olon and Panama City, and thus supplies are rought to the Laboratory. A network of trails has en cut through the forest and these are kept eared. Each route is named. Numbers are posted 100-yard intervals, thus making orientation on e Island and location of points relatively easy. bout 1259 species of plants and trees have been entified.[1] Chapman[2] has described over 230 spe- es of birds. The Island has almost a complete mpling of the animals found on the mainland of anama.[3] Four species of primates are found there nd represent four genera—marmoset, night mon- ey, cebus (capucinis), and howling monkey.[4] The owling monkeys are much less bold than formerly, nd their presence generally is shown only by the laintive howling from the farther parts of the land. Spider monkeys, indigenous to Panama, are ot represented on the Island.

The approach to the Island is very impressive. t rises steeply like a jungle-covered hill from the aters of Lake Gatun, and in fact before the lake as here Barro Colorado was just that—a jungle- overed hill, part of the immense tract of tropical ilderness that stretches from southern Mexico hrough Central America down onto the great con- inent to the south.

The only sign of man's activities we saw was a ong narrow clearing up which led a tremendous light of stone stairs, and about which were scat- ered the buildings of the laboratories and the homes of the few native caretakers. After climbing he stairs, we were shown the roomy well-screened main laboratory building, which serves also as a common dining room and meeting place for the scientific workers in residence. Then we went to our own cabin, a clean and comfortable two-room cot- tage with shower and bath.

We did not have long to wait for our introduc- tion to the jungle. That morning we set out with a group of "Jungle Survival" airmen who were ex- amining possible sites and methods for training pilots who might have to parachute into just such green fastnesses. We were not without a native guide, for Boca Negra of the Laboratory accom- panied us on the trail.

The first trip set before us a whole new world of biological interest. Here a strange, sluggish upside- down sloth hung suspended from a branch. There a great toucan fluttered up as we approached. Giant ants, fully an inch in length and clad in shining black armor, promenaded before us.

Suddenly Boca Negra raised his hand for us to halt and pointed upward silently. There on a high branch was a beautiful yet savage sight. A great white bird, the davilon, perched majestically, a long blood-stained serpent dangling from its beak.

Monkeys somehow seem to typify the jungle. We had heard the strange, distant calls of the howlers several times during our first tramp on the trail. We were introduced to the monkeys in person by the appearance of a troop of cebus monkeys who peered at us curiously and followed us for some distance along the trail. We were back in the Laboratory for a late lunch, and Dr. Zetek regaled all of us with scientific anecdotes and incidents from the history of the Island.

That first evening brought us a minor adventure, but one which we shall long remember. We had stayed in the library, looking over the interesting collections of books and reprints, many of them concerning the fauna and flora of Barro Colorado, until the darkness of the tropical evening had wrapped the little clearing and its buildings in a cloak of obscurity. As we left the library and walked through the quiet and dimly lit main building, we realized two things simultaneously: first, that it was very dark outside, and second, that we had no flashlight or other means of illumination to guide us down the steep and winding stairway which led to our cabin, a hundred or so feet below.

What neophytes we were. True, we had thought about a flashlight in Panama City and usually had one with us on our travels, but somehow or other we had not anticipated such a real need. We decided to light out way by matches—part of the way guided by the dim glow of a match, part of the time feeling our way in darkness. More than once one or the other of us stepped suddenly off the stone stairs and into the grass, only to beat a hurried retreat. Finally we reached the cabin and with the turn of a switch brought back the light and security of the twentieth century. It was not until the next evening, however, that the real climax of that journey through darkness came, when we turned a laboratory flashlight on that hillside and found it literally covered with the burrows of the great hairy tarantulas, the owner and inhabitant of each burrow crouched in waiting close to its entrance.

The nights on Barro Colorado, as no doubt elsewhere in jungle-covered terrain, are not hours of calm peacefulness such as we enjoy in the countryside of temperate climates. They are roistering, clamorous hours of excitement and ceaseless activity. That first night we lay awake for a long time

FIG. 1. Shells of the giant tree snail, *Oxystyla princeps* (Brod.). The larger one is almost 3 in. in length. Both shells have slight defects.

listening to the marvelous concatenation of sounds. Just as we were falling asleep a new sound intruded itself among the others, a sweet, plaintive, liquid whistle which has a strangely human characteristic. This was to be the most impressive of all the sounds of the night. We learned later that it is the call of the tinamou, an odd bob-tailed jungle bird, with some relation to ostrich and to fowl, which inhabits the forest floor and lays beautiful eggs that have blended colors of jade and turquoise.

Workers at Barro Colorado must be early risers. Breakfast is at seven and is announced by a bell that also serves as an alarm clock for the late sleeper. We struck out that morning with the Dunns on the Thomas Barbour Trail. Barbour, of the Museum of Comparative Zoology at Harvard, had been very active along with Dr. Zetek in the establishment of the Laboratory at Barro Colorado and was a naturalist in the grand tradition. Emmett Dunn had studied with him, and so we were made to feel personally acquainted with the scientist after whom this trail had been named.

Our first real collecting came on this day. It consisted in gathering a number of fragmented, and a few whole and perfect, shells of the large tree-snail *Pleurodonte otis otorhinus,* which appears somewhat like a mammoth edition of the flattened planorbids found in our own ponds and streams. The next day we added shells of the second large tree-snail, *Oxystyla princeps* (Brod.), to our collection. This species resembles somewhat a tremendous version of the *Lymnea* of our own acquaintance, with a conical pointed shell (Fig. 1).

The real thrill of our collecting for histologic study began only on the fourth day. We were tramping along the Snyder Molino Trail, keeping an alert eye on the trunks of the larger trees as we passed. Suddenly, just at eye-level, there it was—a big beautiful, living specimen of *Oxystyla.* We picked him off quickly, before he could even sense the presence of alien beings. He was only the first and before noon a half-dozen were in our collecting jars. Emmett Dunn found and contributed a fine living specimen of *Pleurodonte.*

It was on this same trip that I had the honor of finding what was said, unofficially at least, to be the largest serpent ever discovered on the Island. I had been poking about under a large fallen tree when I suddenly saw the glint of a very regular pattern of rhomboidal shapes. They were the scales of a giant boa constrictor, coiled tranquilly in this comfortable spot, no doubt to digest a recent meal. The great fat coils of its body were surmounted by a tiny flattened head, in which the eyes were closed. Dr. Dunn, always the eager herpetologist, was all for waking the creature up to see it in action and view its full length. After a number of attempts to stir the great creature out of its somnolence, including gentle pokes with sticks and movement of the fallen tree for a few inches, we contented ourselves with a few photographs and continued on our way.

The days began to pass more rapidly, but each one was filled with a variety of new adventures and

FIG. 2. Mrs. Andrew feeding a deer just outside of the Laboratory.

experiences. The objects with which we became acquainted early in our stay always had some new aspect of interest. A constant source of entertainment after meals was to sit and watch the Gato Solos playing and quarreling or seeking to walk the tight-rope to secure bits of food strung from it.

A graceful deer took a special attachment to Nancy and often visited our cabin for a tidbit (Fig. 2).

The enormous village of leaf-cutting ants with the thousands of inhabitants coming and going on well-marked trails was always worthy of a stop for observation. Along the paths in the jungle less innocent ants were to be found. Among these was the great black stinging ant, *Paraponera clavata* (Fab.). This ant is fully an inch long (Fig. 3). Army ants in long files were seen frequently and were definitely to be avoided.

The heavy-beaked toucans (*Rhamphastus sulphuratus*) flying across the clearing from jungle edge to jungle edge could be followed easily with binoculars. With these instruments, too, we became acquainted with a huge iguana whose favorite haunt was one of the topmost boughs of a giant tree near the edge of the clearing.

The ponderous nests of the termites ornament many of the jungle trees. A slight scratching away of the surface of any nest reveals myriads of swarming white workers. We were hardly surprised to learn that over forty species of termites have been described from the Island. The total termite population is certainly impressive.

At night myriads of strange insects were to be found near the lights of the Laboratory and cabins. One evening we saw a brilliant green, thin body flutter onto our porch. It was a leaf-like mantis, *Choeradodis rhombicollis* (Latr.), as we learned later (Fig. 4). The mantis of the States is a deadly

FIG. 3. The large black ant, *Paraponera clavata* (Fab.). This insect is formidable in dimensions and stinging ability.

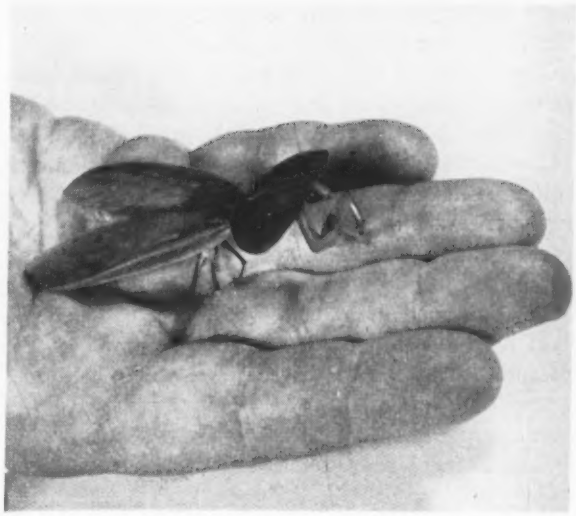

FIG. 4. Specimen of a large, leaf-like mantis, *Choeradodis rhombicollis* (Latr.).

enough looking creature, but here is one which carries his own ambush.

Our work was going well. There was plenty of rainfall and the great snails were present in fair numbers. We had learned how to kill the animal without injury to the soft body and to remove it intact from the shell. The posterior portion of the fleshy body is coiled in perfect conformity to the coils of the shell. In *Oxystyla* the coils are close and tight, in *Pleurodonte* well separated and loose.

One day near the end of our stay we went out with the Dunns to visit the "Big Tree" on the Van Tyne Trail. We had expected something huge, but we were not prepared for the overwhelming size of the great ceiba when we came upon it. There is no way in which to view this tree from a distance, as the growth of smaller trees and tangled vines is dense all about except for a distance of perhaps fifty feet. Its mighty trunk rears directly upward supported by a number of great buttresses. In the dark recesses between these buttresses, where light does not penetrate on even the brightest of days, there are clusters of bats hanging in sleep.

I caught a view of a tiny tree frog climbing nimbly up a vine. Dr. Dunn, who was seeking amphibian eggs, ascended the tree on a ladder of spikes which Boca Negra had prepared. There was a tree hole with water about fifteen feet up, but no eggs were found.

Suddenly Mrs. Dunn called out from the other side of the tree. She had found a fine specimen of the highly poisonous coral snake, its vivid pink coloration standing out against the greens and grays. We were all very interested in seeing it, but as the reptile collection in the Laboratory did not lack

such specimens, we were content to view it alive. Dr. Dunn was excited by a phenomenon which he said was new to him. The snake exhibited a menacing wiggling of its tail rather than of its head-end. On the return trip the only unusual happening was that we ran into a swarm of mites among some bushes and had to assist each other to remove them.

The day of our departure was upon us all too soon. Still, our collections were as complete as we had envisioned them, and while we knew that we had hardly begun to explore the mysteries of the Island, we had come to feel a sense of being at home on the trails and of some familiarity with the many and fascinating living things around us.

Dr. Zetek kindly presented us with two specimens of a large slug (*Veronicella*). We in turn gave him back the "snake kit" which had been lent to us, as it is to other visitors on the Island, "just in case." As we watched Barro Colorado fade into the distance, we felt that here is truly a place which enriches the visitor in biological and personal experience, a place to which some day we surely must return.

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ANTILOCAPRA AMERICANA, THE PRONGHORN

Sole survivor of a once-great family of North American ruminants, the pronghorn differs from the Old World antelopes in having horns with a bony core and a horny sheath that is forked. This horny sheath is shed and renewed annually, whereas the horns of the true antelopes, like those of cattle, sheep, and goats, are never shed. When Europeans first settled this continent, the pronghorn was widespread and abundant, locally outnumbering even the bison. There were not less, it is estimated, than 30 to 40 millions of them on the western plains, ranging from southern Canada to northern Mexico. By 1924, less than 30,000 remained, and the species would soon have become extinct had not adequate protection started. In 1939, a census indicated that the numbers had increased to over 180,000. In 1945 there were over a quarter of a million, and the pronghorn is no longer in serious danger of extinction.

The pronghorn family traces back to the Upper Miocene, perhaps 10 or 12 million years ago, to an ancestral type, *Merycodus*. In the fossil types the horns were generally much more forked than now. The closest relations of the family are with cattle, the family Bovidae.

The pronghorn is a shy but very curious animal. It can run for miles at a speed of 40 miles an hour, and may reach a mile a minute in short spurts. Its habit of erecting its flaring white tail patches as a danger signal makes it very conspicuous on the plains. Even baby fawns a few hours old demonstrate the instinct to do this. The chief predators of the pronghorn are the coyote and wolf, but much more serious is the danger of disease, often carried by parasites such as ticks, lice, and mites. Few American mammals are as graceful and attractive as the pronghorn.

Philosophy of Science in Scientific Education*

LUDWIG VON BERTALANFFY

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MODERN scientific education is presented with a well-known dilemma. The amount of facts in modern science, and in any of its smallest branches, is enormous. Life in general, and the academic curriculum in particular, is short. The abundance of factual data, as well as the intricacy of modern scientific techniques, experimental and theoretical, necessitates utmost specialization. This specialization, unavoidable though it is, involves serious danger for both the education of the scientist and the social function of science.

In so far as the advancement of science is concerned, history shows that interconnection of different fields and problems is a most important basis of progress. Many of the paramount achievements of science arose on borderlines, and from the synthesis of formerly separate fields. This is true of many fields, such as high-molecular, physical, and biochemistry, and virus and cancer research. It applies also to problems that are still under consideration, such as the relation of quantum physics and the theory of the gene, of servomechanisms in electrical engineering and the function of the brain, or the applicability of ecological concepts to human societies. Of course, such integrative fields can be taken care of by making them new fields of specialization with their own departments or subdepartments, and by bringing together, through teamwork, specialists of the branches concerned. This is the obvious thing to do if the field is already established by some clever outsider who, as experience shows, originally was thwarted by all full professors and heads of departments concerned because his newfangled ideas would not fit into the sacred scheme of academic curricula and budgets. But the departmentalization of modern science does little to foster, and much to discourage students to go for adventures in new lines.

Something similar is true for the place of science in general education. It is a platitude that science is one of the driving forces in our civilization. It is equally obvious that science cannot be grasped from the harangues of an inspired lecturer, but only from practical work: making physical experiments, carrying out chemical analyses, looking at cells through the microscope, or dissecting animals. It is, however, less certain whether learning by heart the solution of some differentials, the formulas of some dozens of chemical compounds, or the names of the twenty-nine bones in the human skull, does much for what is called a liberal education.

It is here, I believe, where the philosophy of science comes in. We shall not venture to give a strict definition. Philosophers have debated for more than two thousand years the exact meaning of philosophy without coming to an agreement. Rather I propose to discuss, in a pragmatic attitude, some pertinent topics which seem to be important for the education of the scientist as well as for the general education in our time.

It appears that the main objectives of philosophy of science and, correspondingly, the objectives of instruction in this field, fall under three headings. First, how can the factual data of the individual sciences be integrated into a unitary, although necessarily tentative and fragmentary, world-picture? Second, what are the characteristics and principles of scientific method and thought? Third, what is the impact of science on our civilization?

The need for integration in science is generally

* Address delivered at the Canadian Hazen Conference, June 10, 1953.

understood by scientists as well as educators. For example, a group of scientists, comprising the physicist Bode, the sociologist Mosteller, the mathematician Tuckey, and the biologist Winsor,[1] has urged "The education of a scientific generalist":

> The complexities of modern science and modern society have created the need for *scientific generalists*. . . . We often hear that "one man can no longer cover a broad enough field" and that "there is too much narrow specialization". . . . At all levels, decisions must be made which involve considerations of more than a single field. These difficulties are most pressing in the borderline fields like physical chemistry, chemical physics, biophysics, high polymers, and the application of chemistry, physics, and mathematics to medicine. . . . We need a simpler, more unified approach to scientific problems, we need men who can practice science—not a particular science—in a word, we need scientific generalists. . . . The generalist would naturally be concerned with system problems. These problems arise whenever parts are made into an integrated whole.

Mather,[2] in a symposium on Integrative Studies for General Education under the auspices of the AAAS, discusses the present disintegration of education:

> One of the criticisms of general education is based upon the fact that it may easily degenerate into the mere presentation of information picked up in as many fields of enquiry as there is time to survey during a semester or a year. . . . If you were to overhear several senior students talking, you might hear one of them say "our professors have stuffed us full, but what does it all mean?" . . . More important is the search of basic concepts and underlying principles that may be valid throughout the entire body of knowledge.

In answer to what these basic concepts may be, Mather states:

> Very similar general concepts have been independently developed by investigators who have been working in widely separated fields. These correspondences are all the more significant because they are based upon totally different facts. The men who developed them were largely unaware of each other's work. They started with conflicting philosophies and yet have reached remarkably similar conclusions.

These statements are almost identical with viewpoints that I have advanced myself[3-5] and which have led to the postulate of a general superstructure of science called General System Theory.

There are a number of organizations devoted to integration of science and scientific education, such as the logical positivists with the *Encyclopedia of Unified Science* as their organ, the General Semantics group founded by Korzybski, and the Foundation for Integrated Education. There is a general cry for scientific integration, but it seems that no American or Canadian university does anything about it.

It appears an important task of academic education to show how problems and individual fields are connected in modern science, and how they fit into the modern scientific world-picture. In the following, a program for such a course is given.

Outline of a Course on The Philosophy of Science

The Structure of Nature. A survey of the basic aspects of the levels of organization: elementary units of physics; inorganic, organic, and high molecular compounds; colloidal units; biological elementary units (viruses, genes); organization of the cell; multicellular organization; supraindividual units of life (biocoenoses, animal and human populations in their biological aspects).

The relation of the laws at different levels: physics, biology, psychology, and sociology; application and limitation of physical concepts in biology: mechanistic, vitalistic, and organismic conceptions; application and limitation of biological concepts in the social sciences: body, mind, and society.

Principles of Scientific Knowledge. Observation, experiment, and theory. Model conceptions in science. Induction and hypothetico-deductive systems. The role of mathematics in empirical science. The logical status of laws of nature. Statistical character of scientific laws. Science as a hierarchy of statistics. Attitudes in biological fields: description, comparison, typological concepts. Attitudes in the sociological fields: "nomothetic" and "ideographic" procedures. Laws and individualities. The question of laws in history.

The implications of modern science with respect to the notions of time, space, causality, and finality.

The unity of science. Parallelism in the modern development of the different branches: modern conceptions in physics, organismic conceptions in biology and medicine, Gestalt theory and related developments in psychology, system conceptions in the social sciences. Attempts to create interscientific synthesis. The problem of wholeness. Isomorphic laws in different fields. General System Theory as a way towards unity of science, and as an expedient for a controlled transfer of models and laws from one field to others.

The Place of Man in Nature. Biological foundations: the animal and human body. Neurological foundations: the animal and human brain. Behavioristic foundations: trial and error, instinct, learning, insight.

The uniqueness of man. Language, conceptual thinking, symbolic attitude, tradition, history. The Subconscious and Conscious. General Semantics. The triumph of man's symbolism in his cultural activities. Its dangers and pitfalls. The meaning of civilization.

Of course, this program is only one possible way of organizing instruction in this field, whose aims may also be accomplished in entirely different ways. Fortunately, not even fields like biology, psychology, or economics are standardized, but instruction varies from one teacher and one university to the other. Philosophy of science asks even more for nonuniformity, and full freedom for the teacher's individuality.

There are, however, three general considerations applying, irrespective of the particular program followed. First, with all due respect to the philoso-

sophers, a course in the philosophy of science should be given by a practicing scientist, for only he who works practically in a certain field has the necessary immediate experience of scientific methods and problems. Second, a course in the philosophy of science is not a survey course in the way of Introductory or General Science. Rather, it presupposes that the student has already gained knowledge of facts and scientific methods in one or several fields. Therefore, philosophy of science can only be taught in the senior year of college, and, in more elaborate form, in postgraduate education. Third, and perhaps most important: the program outlined is not Utopian, and it should not be objected that it is too high-brow to be practical. I myself have given similar courses for many years at the University of Vienna, and in the form of university-extension courses. The audience comprised people from the most different walks of life. Since, as usual in Europe, such courses are not taken for credits or degrees, their mere existence showed the interest that there was in them.

Foregoing further elaboration of practical matters, let me discuss a few central problems of the philosophy of science which may help to understand better its role in scientific education. The first is the question of the unity of science.

Probably the most systematic attempt to justify the unity of science is logical positivism, often called physicalism. According to the physicalistic thesis,[6] the unity of science is based upon the unity of scientific language. All terms in physics, biology, and eventually also psychology, are, by means of a chain of "reduction sentences," reducible to the "thing-language" that is common to prescientific and physical language and comprises such terms as stone, water, fire, and rain. These eventually can be reduced to "observable thing-predicates," such as hot, heavy, red, large, and thick. Biological terms, like ox or cell, are either obviously reducible to thing-predicates, or can be reduced to them via appropriate physical terms. So the thesis of physicalism is that all terms in science eventually can be reduced to physical terms and observation-predicates. This is the basis for the unity of science. As far as scientific laws are concerned, there is, of course, at present no possible reduction of biological, psychological, and sociological laws to the laws of physics; but, it may be hoped that such reduction will take place in some future.

Physicalism is correct in contending that there is no place in empirical science for any term or statement that cannot eventually be referred to observation, expressible in thing-language and observation-predicates. However, this is no startling discovery. But it is an absolutely different matter whether or not scientific terms and laws can be constituted in this way. Most emphatically not. Reduction statements or so-called operational definitions do not lead to the establishment of any scientific term. We cannot build up the concept of an atom in physics, or of a gene in biology, starting from observation-predicates, for the simple reason that such predicates are not applicable. An atom is neither hard nor soft, warm nor cold, blue nor red. On the contrary, physics progressively eliminates all predicates that are connected with direct observation and that are, therefore, determined by the specific psychophysical organization of man.

The general trend of science is what may be called its progressive de-anthropomorphization, the continuous elimination of characteristics originating in human sensory experience. For example, optics starts from visible colors; then, all sorts of radiations are discovered that are beyond visual experience, and eventually the theory of light and of electricity are united into electromagnetic theory. The theory of heat starts from hot and cold and their quantitative determination in thermometry. Soon one comes to unvisualizable concepts like that of entropy, and eventually the theory of heat merges with mechanics into an abstract field called statistical mechanics. Not only observable thing-predicates, or what in older terminology are called secondary qualities, are progressively eliminated; the same is true of the so-called categories of space, time, and causality which were considered by Kant as being *a priori,* but which prove, in the evolution of physics, to be all-too-human and are consequently de-anthropomorphized. The Euclidean space of classical physics is in no way identical with the space of direct experience; it is already a conceptual construct. This, of course, applies even more to the space-time of the theory of relativity and quantum physics. In this way, everything that is specific of human experience is progressively eliminated. It has often been considered an argument against modern physics that it is reduced to a mathematical system detached from sensory experience, and hence non-visualizable. But this is a proof that physics liberates itself from our specifically human observation, and is a pledge that physics, in its completed form, if this ever could be attained, does not belong to the human world anymore, but is, rather, of universal validity. Let me make this clear by way of a fiction. Suppose there are rational beings on some planet of the star Sirius who perceive not light but x-rays that are invisible to us. The world in which they observe and live would be completely different from ours. But, in a manner

corresponding to that by which we have detected x-rays and other radiations, such beings would detect those undulations which, for us, are visible light. Probably those beings on the Sirian planet would also calculate and theorize in systems of symbols that are totally different from ours. However, since the system of physics, in its completed state, is a system of purely mathematical relations containing nothing that is human, the same would apply to any other physics. Hence, our physics and the Sirian physics, although different in their expressions and symbols, would have the same content. By an appropriate dictionary, it would be possible to translate the mathematical relations contained in one system into those of the other.

Operationalism and physicalism interpret symptoms of scientific concepts as these concepts themselves. What are called operational definitions or reduction statements, that is, the sequence of statements by which scientific terms and laws are ultimately connected with experience, are only directions for possible ways of testing those concepts. For this reason, different methods are applicable; the symptoms can be interchanged, but science is interested in the invariant expressing itself in different ways.

Science is the representation of certain aspects of the universe in symbolic systems. Scientific terms and laws are constructs, chosen in such a way that consequences which eventually can be tested in experience can be derived. In this sense, these constructs are freely created and provable in, but not determinable by, observation-predicates. In the invention of such constructs lies the creativity of the scientific mind.

Behind the logical thesis that all concepts in science are reducible to physical concepts, there lies a metaphysical motive, although this would be sternly denied by the representatives of logical positivism. This motive is that the world, as pictured in physics, is the ultimate reality. The world consists of those elementary particles called atoms, electrons, protons, neutrons, and the like; and the things observed, whether stars and crystals, plants and animals, or brains and mental life, are aggregates or the outcome of those ultimate realities.

In my opinion, things are different. Suppose we have an antique table. From the standpoint of everyday experience, it is a piece of furniture, brown with some gold ornaments, with four legs, and an oval top. From the standpoint of biology, and examined under a microscope, the table consists of tracheal cells of walnut wood. From the standpoint of chemistry, it consists mainly of a rather complicated compound, called lignin, composed, in turn, of carbon, hydrogen, and oxygen atoms. The atoms themselves are composed of electrons, protons, neutrons, and perhaps a couple of other sorts of elementary particles. We make scientific statements about the table as a thing of physics, that is, we indicate certain relations, called laws of nature, applying to this entity. There is, however, another entity, the table as an economic object. Again, the table may be what is called a baroque piece of furniture, built, let us say, in Vienna around 1770. To speak with Humpty Dumpty, the things in physics are "not realler" than those of everyday life, or those of another empirical science. As a Kantian thing in itself, the table is a baroque object as well as a heap of atoms and elementary particles. The only meaning that can be given to this statement is that, if the thing in question enters the experience of an observer, and if it is agreed what the terms "atom" and "baroque" designate, each observer will make the same statements. We can safely say only that there is a "something" that, according to the frame of reference we apply, is an atomic structure, a mass of cells, and an objet d'art. All these viewpoints are constructs helping us to bring order into experience, irrespective of whether this order belongs to the physical, biological, sociological, or historical aspect. The physical laws governing the play of elementary particles and their union into chemical compounds are not more real than the economic laws governing the manufacture and sale of tables, new and antique.

Thus, as opposed to physicalism, we arrive at a standpoint which, if it has to have a name, may be called perspectivism. Science, as well as everyday reasoning, consists of an array of conceptual schemes that help us to find our ways in the world. Naturally, physics is a better science than biology or the social sciences because its theoretical system is much more elaborate and it allows better predictions. Furthermore, the effort towards explanation of ever more processes in living things by means of physics and chemistry is a most fruitful heuristic attitude. Finally, it is a general tendency in science to integrate formerly separate fields, which amounts to deriving from a minimum of primary hypotheses a maximum of consequences that can be tested in experience. However, any symbolic system that we apply represents a certain facet of aspect of reality. The world picture of physics has no singularity or metaphysical pre-eminence. It does not pertain more to the core of reality than do the others.

I cannot claim originality for this viewpoint. It was expressed by Aldous Huxley much better than I can. Remember those wonderful meditations of

Calamy in *Those Barren Leaves*[2] from which I cannot refrain from giving a short quotation:

> Your hand exists as electrical charges; as chemical molecules; as living cells; as part of a moral being, the instrument of good and evil. . . . Universe lies on the top of universe, layer after layer, distinct and separate . . . like a Neapolitan ice. What's true in the chocolate layer, at the bottom of the ice, doesn't hold in the vanilla at the top. And a lemon truth is different from a strawberry truth. And each one has just as much right to exist and to call itself real as every other. And you can't explain one in terms of the other. . . . The only hope is that perhaps, if you went on thinking long enough and hard enough you might arrive at an explanation of the chocolate and the lemon by the vanilla. Perhaps it's really all vanilla, all mind, all spirit.

As we have seen, the unity of science cannot be based upon the reduction of scientific terms to physicalistic language. The unity of science by way of a reduction of all scientific laws to the laws of physics is, at best, a pious hope. Where, then, is unity of science to be sought? From our viewpoint, the answer is to be expected in some uniformity of the conceptual schemes, the symbolic constructs in science.

If we survey the evolution of modern science, we are witnessing a remarkable phenomenon. Similar concepts and principles have arisen in quite different realms, although this parallelism is the result of independent developments, and the workers in the individual fields are hardly aware of the common trend.[3] For example, principles of wholeness, of organization, of a dynamic conception of nature have appeared in all fields of science. We see them active in modern physics, as opposed to the "blind play of atoms" in classical theory. They appear in biology in the form of organismic conceptions as opposed to the analytical, summative, and machine-theoretical conceptions of the biology of yesterday. They are manifest in the replacement, in psychology, of the older conceptions of classical association psychology by Gestalt theory and related theoretical conceptions. They are found equally in modern developments of the social sciences. Civilizations appear, if not as supra-organisms, as maintained by Spengler, at least as supra-individual units or systems, as expressed in Toynbee's conception of history. Thus, similar general viewpoints are present in all branches of science, irrespective of whether inanimate things, organisms, or mental or social phenomena are concerned.

This parallelism goes even farther. In many instances, we find a formal correspondence or isomorphy of laws in different sciences, in different fields or strata of reality. The same exponential law, for example, applies to the decay of radium, the death of bacteria under the action of a disinfectant, the extinction of a population where death rate is greater than birth rate, and many other phenomena. Systems of chemical reactions are governed by the same kind of equations that apply to the struggle for existence within animal populations, and to economic problems. There are hardly phenomena more different than the development of whole animals from divided animal germs, the regulations in the nervous system after injuries or resection of parts, and the phenomena of Gestalt perception. Nevertheless, the principles governing all these phenomena are strikingly similar. To take an example from the social sciences: in the history of Germanic languages, it is found that, starting from a certain parent language, phonetic changes have taken place in a parallel way in different nations inhabiting widely separated areas. A similar principle of independent but parallel changes is well known in many evolutionary series in paleontology.

In this way, there is a uniformity or isomorphy of laws in different fields. One of the roots of this isomorphy is obviously that the number of conceptual schemes or models we possess is not infinite but rather limited, so that similar schemes will appear in quite different fields.

This fact has led to the postulate of a new basic discipline called General System Theory.[4, 5] General System Theory is a logico-mathematical field concerned with the principles applying to systems in general, irrespective of the nature of their component elements and the relations or "forces" between them. Such theory leads to an exact formulation of many terms which have, as yet, been conceived in a vague, anthropomorphic, or metaphysical way. The fact that all sciences mentioned are concerned with systems, leads to formal correspondences in their general principles, and even in their special laws if the conditions correspond in the phenomena under consideration. Methodologically, a general theory of systems can develop model conceptions applicable to different fields, and so make unnecessary the duplication or triplication of the discovery of identical principles in different fields, as it has often occurred in the history of science.

This has considerable implications for the question of the unity of science. So far, the unification of science has been seen in the reduction of all sciences to physics. We have seen, however, that, in so far as scientific terms are concerned, they are hardly reducible to physicalistic language. If unification of science is seen in the reduction of all scientific laws to physical laws, this could be achieved, if ever, only in an inscrutable future. From our

point of view, unity of science gains a much more concrete aspect. A unitary conception of the world will be based not upon the possibly futile and certainly farfetched hope finally to reduce all levels of reality to the lowest level, but on the structural isomorphy of laws in the different fields of science. In particular, the gap between the natural and the social sciences will be diminished, not in the sense of a reduction of the latter to biological conceptions, but in the sense of structural uniformities.

It seems that the viewpoint that I have called perspectivism goes a long way in understanding the dignity as well as the limitations of science. Science is not a mere accumulation and catalogue of facts. It is a conceptual order we bring into facts. Science is not primarily a cookery book for inventing new gadgets. Applied science is possible only on the basis of detached fundamental research, technology being able to invent new applications exactly so long as the prerequisites are given by pure science; and there is a considerable danger of exhaustion. The present way of premium given to applied science, and of making basic science an ill-paying job for incorrigible idealists may, in not too remote a future, frustrate new theoretical developments and, as a necessary consequence, even technological progress. Science is a creative activity, and its fundamental advances are in the adventure of bold constructs, always checked by, but never simply resulting from, a mere increase of data. Science is not a materialistic or mechanistic metaphysics, reducing physical things, life and mind to a senseless play of atoms. It is one of the ways man has created to portray certain traits of reality and to control his destiny.

It seems to be one of the tasks of scientific education and of the philosophy of science to make clear this austere but unavoidable conception of science and to destroy popular illusions that are ingrained and common. Judging from the popular magazines, science means, first, new gadgets: the most brilliant television set, the fastest jet plane, the most devastating atomic bomb, and the new wonder-drug curing tuberculosis or cancer or arthritis or, preferably, all of them. Further, it means scoops or freaks: the galaxies farthest away, the quintuplets, the conversion of a G. I. into a girl with a subsequent Hollywood contract. Above all, it means progress, faster cars, more labor-saving devices which give more leisure to study comics, to hear advertisements of washing powders via the radio, and to watch soap operas on the television screen.

In our days, we can no longer conceive of science as being the superhighway to Utopia. Or perhaps it is, but Utopia is not so good a place to live in. It is obvious that telephones, refrigerators, and antibiotics are good things. It is less obvious whether movies, television, and other forms of mechanized entertainment are exactly cultural achievments; and machine guns, atomic bombs, and bacteriological warfare are definitely unpleasant. Whether, in the overall picture, the benefits of science compensate for its disadvantages, nobody is able to tell. It is disconcerting to proclaim science as being the motive force in our civilization if, in the next breath, it must be confessed that civilization may be smashed by a few atomic bombs. What a world governed by a strictly scientific and, for that matter, benevolent tyranny would look like, we know quite well since Aldous Huxley wrote *Brave New World* some twenty years ago. We are not so advanced as to breed human beings *in vitro*, and so to guarantee genetical homogeneity to the castes of society, but modern governments are pretty good already in standardizing public opinion by way of conditioned reflexes. Science cannot be justified by utilitarian reasons, nor be explained as arising from economic causes.

Science as the Sacred Cow is another popular illusion. The prestige of science and the domination of the modern world by science are fairy tales invented by college professors in order to compensate for their inferiority complexes. Scientific achievements are employed to precisely the extent politicians and businessmen see fit—that is all. Other equally important and far-reaching results are disregarded. Thus, science can predict very well the consequences of the devastation of our natural resources, of deforestation and of the erosion of the top soil; ways are known to increase yields in underdeveloped areas to a multiple of the present standard. But deforestation goes on, to print pulp magazines; and crops are controlled, to keep prices on the world-market stable. If a scientist is needed to prove that a chlorophyll toothpaste is the best against halitosis or if he is needed to make atomic bombs, he is paid a high salary indeed—that is, a fraction of the wages of a fashion model, a television starlet, or a junior executive in a firm selling brushes. The highest scientific award, the Nobel Prize, amounts to somewhat less than the purse in a minor boxing championship. Since the best authorities agree that economic values are determined by the law of supply and demand, it is obvious that the discovery of penicillin or of quantum mechanics has less "societal value" than knocking out the other tough fellow.

What, then, are we going to offer if it is one of the tasks of the philosophy of science to render an evaluation of science? The answer, I believe, was

given by G. B. Shaw's *Don Juan*. Like civilization, science is "an excellent peg to hang cynical commonplaces on; but before all, it is an attempt on Man's part to make himself more than the bare instrument of Women's purpose."

It remains to be seen whether the march of science is triumphal or macabre. One thing, however, is certain. Science is one of those symbolic worlds man has created for mastering the great enigma of the universe, the creation of which is part of his uniqueness. All reasoning consists in the substitution of symbols—concepts, words, mathematical signs—in lieu of reality. Through its immanent logic, this system of symbols gains, as it were, an existence independent of and surpassing the individual life and psychology of its builders. It is in this way that science, in theory, leads to prediction, and, in practice, to the control of nature. The technological mastery over natural events demonstrates that the theoretical system is more than a castle in the air, that it corresponds to certain traits of reality.

However, none of the worlds of symbols, the sum total of which is called human culture, is a full presentation of reality. Remember those precious etchings by Whistler: the lagoons of Venice, the bridges, San Marco and its doves—just a few scratches of the needle, giving, nevertheless, an unfathomable perspective of Italian serenity. Whistler called painting the art of omission representing things by a few characteristic traces. Something similar is true of science. It is not concerned with the innermost core of reality. But it is one of the perspectives of reality, representing, by means of interconnected symbols, certain traces of reality, namely, the orderliness in the relations of things. This, however, is sufficient to allow for theoretical as well as practical mastery of nature.

It is said, and it is true in a way, that the prelude of Wagner's "Rheingold" gives a picture of creation: moving upwards from the keynotes of the flowing element to ever higher and more organized, life-imaging melodies, till finally the voice of the elfish daughters of the Rhine emerges. It will be difficult, however, to learn much about the evolution of the vertebrates from Wagner. Da Vinci's "Gioconda" fortunately reveals little of human anatomy as represented by that admirable lady, although, incidentally, Leonardo was a keen and quite modern anatomist. What science can do is to symbolize reality in its way, knowing, as its great masters always did, that this is but a humble way to redraw a few traces of the great blueprint of Creation.

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Small-Town Fluoridation Fight

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THE question of fluoridating the local water supply first came to the attention of our town when it was placed on the warrant or agenda for the 1952 town meeting. At the time most people gave fluoridation little chance for our town is traditionally conservative, particularly on public health issues. However, at the town meeting there were persuasive speeches citing the experience of other towns and cities in greatly reducing dental decay among children by adding minute amounts of fluoride to the water supply. Two local dentists testified that the American Dental Association had endorsed fluoridation as a safe and effective way to reduce dental decay. So, unexpectedly, the measure passed by the overwhelming vote of 302 to 2.

But this was only the beginning of what was to prove a long story—a story by turns tragic, comic, and frightening—and a story with many ramifications. The issue of fluoridation itself, while surely not of as great magnitude as many which come to public attention, is by no means unimportant. A state public health official recently characterized it as one of the best gifts which any town might give its children. But beyond the immediate issue, the controversy that it raised in our town has presented, in capsule form, many of the urgent and unsolved problems of public discussion in a democracy.

The scene of the story is a small picturesque and rather isolated New England town. Of its approximately 5000 population a few hundred are connected with the local college; another several hundred are professional people, many of them connected with local and nearby industries; the rest are laborers (local industries are nonunionized), small businessmen, farmers, and retired people. Long-time residents look with scorn and suspicion on newcomers. It is sometimes said that a man must have lived here for twenty-five years before he applies for naturalization.

Soon after the town meeting there were rumblings of opposition. As a consequence, the selectmen acted slowly in carrying out the voters' mandate. But when the opposition failed to materialize by midsummer, they investigated and placed an order for equipment. It did not arrive until January, 1953. By that time opposition was vocal and vigorous. An item was placed on the warrant for the forthcoming 1953 town meeting to rescind the action of the previous year and to sell the recently purchased equipment. In the face of such developments the selectmen decided not to operate the new equipment until after the 1953 town meeting, scheduled for early in February. Advocates of fluoridation asked what authority the town fathers possessed to stall in carrying out the people's vote. Some charged that the selectmen had dragged their feet throughout the year. Meanwhile, those who claimed to have a finger on the public pulse, predicted that flouridation would be overwhelmingly rejected.

The opposition expressed its views in a series of letters to the local paper. One letter charged that fluoridation was a dangerous practice, foisted upon the town by an evil alliance of misguided doctors and the companies that sell fluoridation equipment and supplies. Another said that fluorides were rat poison, and that if an enemy were to gain control of the town water supply our whole population could be silently and efficiently exterminated. Several charged mass medication and socialized medicine. Another letter asserted that too little is known about the subject and asked for an unbiased and expert committee to study it. Others cited data alleging to prove fluoridation harmful to the sick, aged, and to pregnant women. Cities which had adopted fluoridation were claimed to show a marked increase in heart disease, kidney disease, bone fluorosis, mottled teeth, stillbirths, and a variety of other maladies. Some added bluntly that they just didn't want any more chemicals in the drinking water.

Opposing attitudes ranged the whole spectrum of belief from the thoughtful conservatism which argued that we ought to wait a few years until more is known, to the dogmatic and frantic assertion that fluoridation is a satanic (or communist) plot. Individuals known throughout the region for their opposition to such measures as pasteurization, compul-

sory vaccination, and chlorination of water, entered the discussion and made their views heard.

Advocates of fluoridation sought to meet the issues. They read scientific articles and wrote letters to the paper, stating facts and figures from the Newburgh experiment, giving statistics from areas of the country where fluorides occur naturally or are added to drinking water, showing that dental health is greatly improved and also that no harmful results follow. The opposition countered with the distinction between fluorides which occur naturally, "as God made them," and "man-made," or artificial fluoridation, the former being beneficial and the latter harmful. They also quoted the Report of the Delaney Congressional Committee with its counsels of caution and its suggestions of possible long-time harmful results. A *Harper's Magazine* article entitled "Fluoridation—Go Slow," was widely read. Opponents spoke darkly of local doctors who were "agents" of sinister but unspecified powers and of dentists who were promised a cut in the sale of fluoridation equipment and supplies. But above all, they bore down on the argument that the long-time effects of fluorides are unknown. Who knows their effects? Who knows? Who knows? They repeated this with almost hypnotic effect.

Advocates sought arguments to stem the tide of misgiving and fear. They pointed out the high rate of dental decay in our region. They read and analyzed the Delaney Report, with its inaccuracies and its innuendoes, and also the American Dental Association's devastating analysis of the report. They mimeographed and distributed figures for death rates in regions having fluoridation, showing no divergence from the rates of the country as a whole. They argued that the issue came down in the end to a question of whom the people are to believe, of what authority they are to trust. On the one hand were the American Dental Association, the American Medical Association, the Federal Public Health Service, the state health board, the American Waterworks Association, and many other reputable and competent organizations which have endorsed fluoridation. On the other hand were the few individual doctors, dentists, scientists, and self-constituted local experts who questioned or opposed it.

Feeling ran high at two preliminary public meetings where the issue was discussed. At one meeting, called by the League of Women Voters for the purpose of discussing the warrant for the town meeting, there were speeches pro and con. One opponent raised the issue of constitutionality, arguing that fluoridation is an infringement of individual liberty and citing legal decisions purporting to prove the point. Another spoke of an alliance between local "so-called doctors" and the Aluminum Company of America, which would presumably supply fluorides. She also stated knowingly that Oscar Ewing, recent Federal Security Administrator, had formerly been an official of the same company.

At another meeting called by advocates of fluoridation, there were speeches by a representative of the United States Public Health Service and by a medical man with years of research experience in fluoridation and its effects. Opponents came to heckle and filibuster. The net outcome of the meeting was aptly expressed in the newspaper headline, FLUORIDATION DISCUSSION LEAVES 125 MINDS UNCHANGED.

A climax was reached at the town meeting. Of a total of approximately 3200 registered voters some 600 turned out, a fairly good number and about all the local school gym will hold. Many had come to vote only on this issue. Feeling ran so high that when this item on the agenda was reached, the moderator called a ten-minute recess. He introduced the issue with an appeal "not to let angry passions rise," saying that he would alternately recognize pro and con speakers.

The first speaker, an advocate, urged the meeting to defeat the motion to rescind, emphasizing the benefit of fluoridation to children's teeth and the recognized safety of the procedure. The first opposition speaker, a man well-known in town meetings for his practice of making speeches in opposition to almost everything, said that in his observation our children's teeth are good, but that few people over fifty have stomachs that are worth anything. He did not spell out the implication that fluoridation was harmful, but the point seemed widely understood.

A doctor who is a member of the town health board, and who had studied the issue carefully and extensively, explained the experimental work which had led up to its approval by the dental and medical associations. He also described the scientific investigations supporting the conclusion that fluorides in the amount contemplated are harmless to everyone, old and young, sick and well. An opposing speaker dwelt upon the possibility of poisoning the whole population if excessive amounts were dumped into the water supply at one time. Scientists attending the meeting writhed in silent anguish while the speaker confused and misconstrued elementary scientific facts. Another doctor and two dentists added their testimony that fluoridation was a safe and a desperately needed step toward better health.

An opposition speaker said that her ancestors had fought for their lives in this region against the Indians and that the time had come to fight with

equal vigor against fluoridation. She said that it had been proven useless and harmful in many cities and she defied the proponents to deny this. A local lawyer stated that he had checked the legal issues and that in his opinion fluoridation was legal in our state—an opinion in which the state's attorney general had recently concurred. A final opposition speaker, sensing that the tide of argument was running against her side, made an impassioned plea for the "little people" to rise against authority. They had done so in the American revolution, she argued, and should do so in the present emergency, defending the right of the individual "to control what goes into his own body."

The vote was a victory, 291 to 249 for fluoridation. Proponents heaved a sigh of relief, thinking that the cause of science and public health had been vindicated in our town. The result was headlined in the newspapers of many surrounding towns and cities. However, the relief was premature. Feeling was still intense and bitter; one person who had spoken for fluoridation in town meeting was accosted on the main street of town as a "stinker" and a "communist." One of the leading opponents of fluoridation said to a friend as they left town meeting that their work was now cut out for them. Meanwhile, instructed by two successive years' town meetings, the selectmen proceeded to put the fluoridation equipment into operation. Newspaper articles and pictures heralded the event and state health officials described inspection procedures and safeguards. One lady telephoned the water department complaining of stomach pains which she attributed to the fluorides, only to be told that she lived in a part of town supplied from a reservoir not then being fluoridated.

For a few days the town wondered if the issue would be dropped. This uncertainty was soon removed. After a series of discussions an Anti-Fluoridation Association was organized, officers elected, and a statement formulated, charging the moderator of the town meeting with bias, alleging that illegal votes had been cast, and raising the issue that the whole meeting had been illegal since it had been held in a hall too small for all the town's 3200 registered voters. The last charge, which is technically correct, would invalidate all of our town meetings for many years past. They made plans and raised funds for a hard campaign. They circulated petitions asking for a special town meeting at which there would be a secret ballot on fluoridation. The work was done thoroughly, and as a result 932 signatures were secured for the petition. The committee reported mysteriously that several other pages of names had been stolen from their headquarters.

The campaign against fluoridation gained momentum. Flushed with success in the petition, some members of the Anti-Fluoridation Association boasted that once they had won this fight they would turn their attention to other issues of good government. They did not specify what they meant. They continued to fan the flames of fear. Fluoridation is harmful to the kidneys, to the heart, and to the bones. Who knows what results may follow from its use? Who knows?

This phase of the campaign came to a climax in a public meeting, billed as The Facts on Fluoridation, and addressed by three dentists opposed to it. The leading speaker was billed as senior dental consultant of a well-known hospital in our region. A phone call revealed that the position is purely honorary, that he is not at present a member of the hospital staff. He claimed to have the signatures of 119 dentists in his city who are opposed to fluoridation. The signatures turned out to be several years old, a large percentage of the signers having subsequently changed their minds and endorsed fluoridation. At the meeting a package of sodium fluoride labeled "Poison" was plainly displayed at the front of the room. At the opposite side of the platform was a large container of nonfluoridated water from which the speakers drank freely during the meeting. The speeches rehashed the half-truths, the discredited arguments, and the misinformation. A few supporters of fluoridation who attempted to ask questions were heckled. The meeting ended with a spirited diatribe from the floor against the current addition (without popular mandate) of a water softener in our water supply.

The proponents of fluoridation were puzzled to know what course to take. If a large number of people were frantically opposed to fluoridation, however invalid their reasons, was it wise to press the issue? It was felt that misstatements of fact should be publicly corrected. But in limited time and without an expense account, it was impossible to trace and check all statements. Furthermore, a correction, however fully and accurately documented, did not in this case, as so often it does not, undo the effect of an original false statement. It seemed to them that many people were not open to facts, often rejecting carefully stated factual evidence from competent and reliable authority in favor of gossip and hearsay based upon the flimsiest evidence, and full of loopholes and contradictions. But most of all, proponents of fluoridation were puzzled to know why this issue had generated so much heat that long-time residents of the town can remember nothing comparable.

Seeking answers to such questions they recog-

nized a basic error in strategy in bringing the issue to a vote without a long and thorough campaign of education. Failing this, they found that they had a tiger by the tail.

They also noted that the issue was made to order for exploitation by fear and demagoguery. It is a highly technical question on which only a few trained experts have any first-hand right to an opinion. The public, knowing little or nothing of the technical questions of chemistry and biology, and hearing claims and counter claims bandied about by self-styled experts, is justifiably puzzled as to whom to believe. While all major medical and health organizations have endorsed fluoridation, there is a small minority of dentists, doctors, and scientists who have misgivings or are opposed. The public asks, "Since the experts disagree, should we not wait awhile?"

No science, except perhaps pure mathematics, ever achieves complete certainty in its results. What it offers is an impressive body of overwhelmingly probable facts—facts which gain in probability with each successful experiment but which never achieve complete certainty. Moreover, scientists, as men of intellectual integrity, do not want to claim too much for their results. Thus, when a scientist is asked to give absolute assurance for what will take place in the distant future he hesitates or demurs. But this limitation of scientific knowledge provides the opening wedge for deep-seated fear. So the unanswerable question recurs, "Who knows what results will follow?" Who knows? Such fears are also accentuated by the new and unfamiliar nature of the scientific processes involved in fluoridation.

Deeper than any specific fears or issues lies a free-floating fear or anxiety in the subterranean depths of men's minds. This unreasoning anxiety attaches itself to different and often unrelated issues. Thus, questions as far apart as Senator McCarthy's investigations and the fluoridation of a small town's water supply show a similar emotional pattern. It is this attitude, expressed in so many ways, which has led some observers to charge that American public opinion is in the grip of a fear psychosis. In our town this fear psychosis found a vehicle in the fluoridation issue. Health issues impinging directly upon individual lives have been effective in dredging up such fears, from the first days of compulsory vaccination to the present. The fruits of this fear, in bitterness, dogmatism, charges of guilt by association, misrepresentation of facts—as often to oneself as to others—suspicion, and intolerance of any disagreement, were all illustrated in our controversy.

But perhaps the most fundamental attitude was a deliberate rejection of reason and rational authority by the antifluoridation forces. In an age when storms of unreason have swept like devastating floods over many nations it is significant to trace such attitudes to their source in fear. Truly, big lies from little misstatements grow when they are fed by fear.

A further observation is the ineptitude of the time-honored New England system of direct democracy in the face of attitudes and problems of this sort. Any sharply controversial issue tends to disfranchise those citizens who are dependent upon public goodwill. For this reason many merchants in our town have stopped coming to town meetings. Systems of indirect or representative democracy provide means for giving weight to expert opinion on technical matters. No such means exists in the town meeting system.

As the time for the secret ballot drew near, the Anti-Fluoridation Association bought advertising space in the local paper, repeating and underscoring its charges. A crescendo was achieved the day before the election in the warning that fluoridation would produce a "third generation, degenerated to crippled Pygmies." The only organized effort of the profluoridation forces was a letter to the newspaper, signed by six of the seven local doctors, stating that they had faith in the reliability of federal and state health agencies, and that in their opinion fluoridation would be both beneficial to dental health and harmless to the population at large. A college professor of science pled in newspaper letters for reason against emotion. The result was a vote, 1114 to 415 against fluoridation. It was an authentic social revolt on the proto-fascist pattern. Advocates suggest that in a few years after emotions have cooled and public judgment is restored, the issue can be raised again and can receive a fair hearing. Opponents reply that fluoridation will take place in our town over their dead bodies.

Responsibility of the Scientist to Society*

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SCIENCE has developed in the last three centuries from an intellectual pursuit of a small minority of curious and sometimes gifted amateurs to a professional activity of thousands of highly trained members of our population. It has changed from an activity in which the masses had essentially no interest to one that has become front page news. It originally gained many of its answers from practical men—miners, navigators, arms makers, barber-surgeons, herb collectors—and contributed little in return. It now draws little from technology and contributes heavily in return.

The sudden rise of science as an intellectual activity has naturally created social problems of first magnitude. Science has not only had a physical effect in changing man's material way of life but has resulted in mental upheaval as well, the latter a result of changes in man's understanding of nature and in his attitude toward knowledge. Bringing about such changes in the culturally short period of three centuries—and much of it in the past century—could not help but create problems defying solution.

We may well raise the question, "What is the responsibility of the scientist to society?" The question has been the result of much discussion on the part of both scientists and non-scientists. The answers range from one extreme to another. On the the one hand we find those who advocate a moratorium on scientific activity as did the Bishop of Ripon when he declared in 1927, ". . . the sum of human happiness outside scientific circles would not necessarily be reduced if for ten years every physical and chemical laboratory were closed and the patient and resourceful energy in them transferred to recovering the lost art of getting on together and finding the formula of making both ends meet in the scale of human life. . . ."† Contrasting with this negative approach to dealing with the impact of science on society there is the irresponsible exploiter of applied science who holds that man is by nature a competitive creature so he must be left free to do as he wishes. This person insists that the scientist has no responsibility to society—or may even insist that the scientist's responsibility is to keep out of social affairs so that commercial success can be left solely to, "the play of the market place," to quote a currently well-known Secretary of Commerce.

To me it seems that neither of these solutions is realistic. The Bishop of Ripon and those of like mind wish to ignore the whole problem by returning to the *status quo pro scientia,* or failing to attain that problemless golden age they will settle for the *status quo pro 1927.* They would give up the lengthened life span that can be traced back to the studies in optics leading to the compound microscope (and through the compound microscope the knowledge of the living cell, the germ theory of disease, and chemotherapy). They would give up the material comforts of living in an age of diversified diet, varied clothing, rapid transportation (even with its attendant evils) and rapid communication. They would give up a system of production which, in the more advanced countries at least, has made possible a degree of leisure permitting educational opportunities to be extended from the aristocratic classes to the masses.

The second critic of science, who would permit the scientist merrily to develop practical things as long as he took no responsibility beyond develop-

* Originally presented before the First Unitarian Society, Madison, Wis., on July 27, 1953. Broadcast over the Wisconsin State Radio Network July 31, 1953.

† Bishop of Ripon, (London) *Times,* September 5, 1927, p. 15.

ment, strikes me as equally dangerous. He is the advocate of a return to the law of the jungle. He closes his eyes to the fact that human civilization is a cooperative enterprise—that civilization rose not because of competition but in spite of it. Whenever men have banded together to accomplish a feat not possible for single men there has been progress in the control of the environment. Whenever control of the environment was uniquely successful there has resulted a period of cultural development. It was then that some men had the leisure and the freedom for intellectual pursuits—philosophical, artistic, social, scientific, technological. It has been then that understanding has developed, and with understanding—particularly scientific understanding—greater measures of control of the environment. Let us beware of any plea which would have us abandon the cooperative way in favor of unbridled competition.

What then should be the position of the scientist regarding his obligations to the social order? Should he proceed with his chosen work oblivious to the consequences of his investigations? Should he drop his work in order to apply his talents to the social problems that have been created by science? Or is there a rational middle course to be followed? It seems to me that there is no one answer that suits all situations, though I lean toward a middle course.

It would seem desirable that the investigator be given a large degree of freedom to pursue his researches without thought of possible effects. I feel this way because so much research is without social significance, at least at the moment. In fact, the future significance of much investigation is highly problematical. This is particularly true of what is called "pure research," or by some "worthless research." We cannot hold the investigator responsible for the impact of discoveries whose effect may only make itself felt several generations later—and felt in unforeseen ways.

Take the researches of Michael Faraday for example. Among the many things studied by Faraday at the Royal Institution was the relation of electricity and magnetism. The experiments of Oersted had revealed that electricity flowing through a wire set up a magnetic field—at least a compass needle nearby was deflected. Faraday became interested in these experiments, not because he had a burning desire to create the electric power industry but because he had a simple faith in the unity of nature. Here was a hitherto undetected relationship between electricity and magnetism. Greater understanding of the relationship might lead to better understanding of all of nature and Faraday carefully pursued electromagnetic researches for two decades. He sought to convert magnetism into electricity since, he reasoned, if an electric current was accompanied by a magnetic field, should not a magnet be capable of creating an electric current? The question was not answered at once. Such questions seldom are in science. The most obvious experiments were failures. But in time the phenomenon of electromagnetic induction was discovered.

These researches were fundamental to the generation of electric current by mechanical means and led ultimately to the electric power industry. It is possible to say, in a rather loose sort of way, that Faraday was responsible for commercial electricity in all its manifestations. We may conceivably honor Faraday for the comforts he provided whenever we turn on a reading lamp, an electric stove, or a vacuum cleaner. Or we may curse him for creating a monster when we lose our savings in an Insull debacle or when a promising young man is electrocuted while repairing a power line.

Such attitudes, however, are not only unrealistic but dangerous. They oversimplify the whole story by ignoring nearly all the facets in the development of electrical power. They ignore the fact that Faraday had no intention of creating a new source of power and had no conception of the future impact of his experiments on electromagnetic induction. They ignore the fact that Faraday never attempted to develop a commercially practical dynamo. It was nearly four decades after Faraday's fundamental researches that the Belgian engineer, Gramme, developed such a dynamo. They ignore the fact that Faraday dropped these experiments in favor of researches on the influence of magnetic fields on light. They ignore the fact that the time was ripe for the discovery of electromagnetic induction; that is, the previous fundamental steps had been taken so that someone was due to make the discovery. In fact, Faraday was actually anticipated in some of his discoveries by the American Joseph Henry.

It is clear from my example that it is absurd to insist that Faraday is responsible for the good, or the evils, of the electrical industry. All that we can honestly say is that he played a role in the development. Beyond that, he can neither deserve praise nor blame. His motive in carrying out his researches was not one of commercial development but the more important one of gaining a slightly better understanding of nature. He was investigating pure science or, as some would say, he was doing impractical or worthless research.

Let me make a plea for the freedom to do worth-

less research. It is the worthless research of today which stimulates the technological progress of tomorrow. True, much of the worthless research remains buried in the scholarly journals unused. One may argue that the time spent on such investigations has been truly wasted. This waste is inevitable and is not actually too serious a waste since positive knowledge, even if nonutilitarian, represents a gain in understanding. But the main point we must consider is that no one is so all wise that he can know which piece of worthless research will remain a mere addition to man's knowledge and which will become basic to practical developments. Therefore, it is necessary and desirable freely to probe into the unknown solely for the sake of advancing knowledge. In doing so the scientist must not be held responsible for the long-range effects of his discoveries.

In view of the foregoing statements it must not be supposed that I feel that the scientist is without responsibility to society. As a citizen, he has the same responsibilities of good citizenship that are expected of any other member of society. As a highly trained person, society has a right to expect more of him than it expects of most. This is particularly true of the area of his competence. Here the scientist is in a position to speak with authority and he has an obligation to give society the benefits of his position. At the same time he has an obligation to bow to superior wisdom when he is outside his field of competence. All of us, I am sure, have seen respected members of a given field, say medicine or banking, speak out loud and long on problems of economics, politics, and religion. We are familiar with books on religion written by scientists who speak with a lack of objectivity sometimes equaling that of the most bigoted fundamentalists.

What, in particular, are the areas where the scientists are best fitted to make a contribution to society? As I see it the scientist has the right, even the obligation, to speak and act in the following areas which I shall indicate as the governmental, the sociological, and the educational. Let us first consider the *governmental area.* In this area the scientist has the obligation to preserve the freedom of science. This implies a number of things.

First, there must be a reasonable freedom to investigate problems of one's choice. The scientist who is not free to undertake or reject a proposed research problem is a slave. His acceptance or rejection may be based on degree of interest, competence, or conscience. He must be allowed reasonable freedom to make a choice on any of these bases. I do not mean to imply that an employer—be he governmental, industrial, or institutional—has no right to establish research problems and ask his employees to work on them. I do want the employee to have reasonable freedom to change employment if his assignments are personally unsatisfactory.

Second, there must be freedom to make one's own decisions on conceptual matters. When the scientist is told which theories he must accept and which are to be rejected, then science is placed in a straight-jacket and progress cannot help but be stifled. We have seen this sort of thing happen too often in our own generation—in a Nazi Germany where the "Jewish physics" of Einstein and Planck was *verboten*; in Soviet Russia where by state compulsion biologists have been forced to abandon the genetically fruitful concepts of Mendel and Morgan to pursue the decreed genetics of Lysenko, and where the chemists have been ordered to abandon the resonance theories of Linus Pauling. Every true scientist has an obligation not only to science but also to society to protest long and vigorously against such science by decree, whether it be in a foreign country or his own. It has been gratifying to notice how our own scientists rose up en masse to protest Secretary of Commerce Weeks' interference with the operation and integrity of the Bureau of Standards in the AD-X2 battery additive case. It is likely that the administration will proceed with greater caution in the future as a result of learning the temper of America's scientific men.

Third is the obligation to insist on the free dissemination of new scientific findings. Progress in science has always been due to the sharing of new information. We can observe this for instance in chemistry. The study of the nature of matter was carried on for a millenium by the alchemists with little semblance of progress. The thought of the alchemists was dominated by the Aristotelian concept of the elements. This concept erroneously suggested the possibility of the transmutation of the elements (i.e., making gold out of lead). In following this will-o'-the-wisp the alchemists had excellent opportunities to gain an understanding of matter. Instead of transmitting their knowledge freely they disguised their discoveries in allegorical mysticism. This thousand-year period of chemical stagnation is in marked contrast with the past two centuries when chemistry has made remarkable strides. In part, the recent progress must be attributed to the discard of ancient philosophical concepts. However, the progress could not have been rapid without the development of a new outlook regarding the sharing of new discoveries. In contrast to vague symbolism there developed among natural philosophers in the seventeenth century a feeling of responsibility for the dissemination of new knowledge. The *Accade-*

mia del Cimento in Florence, the Royal Society in London, the *Académie des Sciences* in Paris all included among their activities the publication of new findings.

This tradition of early and complete publication must never be given up. If the world's scientists cannot benefit from the new discoveries of their colleagues science will begin to stagnate. Instead of working on the frontiers of knowledge scientists will spend their time duplicating one another's experiments.

These remarks naturally raise the problem of national security and scientific censorship. It can be argued with some reason that here is a place where censorship is justified. What shall be the proper attitude of the scientist? Clearly this must be an area for compromise. It is reasonable to withhold information that is of value to an enemy intent upon destroying one's way of life. But we must be careful not to stifle science by a rash policy of thoughtless censorship. The real problem lies in the decision of what to censor. Just what is valuable to one's enemy and what is useless? Not too much damage will be done to science if technological details are withheld, but if fundamental discoveries are withheld, one may handicap one's friends as much as one's enemies and do long-standing damage to science. Further, it is the fundamental discoveries which are hard to recognize since they often bear no apparent relationship to later developments. It would be easy to withhold the inconsequential and reveal the vital discoveries. The only real solution is to strive for international relations where censorship is unnecessary.

The difficulty is revealed in the activities leading up to the development of nuclear energy. All the fundamental discoveries in this field had been made by the time publication was brought to a close early in World War II. Without access to these findings no nation could have developed the atom bomb. With this knowledge, any nation willing to expend sufficient human and financial resources could have created the weapon. Now suppose that a group of pacifist scientists had anticipated the development of nuclear energy. Just where would they have instituted censorship in order to block effectively the development? Let us examine the sequence of discoveries.

The discovery of radioactivity was made in the laboratory of Henri Becquerel, a Frenchman, in 1896. He was extending into the area of mineralogy the fluorescence phenomena observed by Röntgen, the German who discovered x-rays just the year before. Röntgen's experiments were the outgrowth of developments made in cathode ray tubes, apparatus used in studying the conductance of electricity by gases. Such experiments had been pursued by the German Plücker from 1859 and extended by Hittorf and Crookes. Experiments with such tubes also resulted in the discovery of positive rays (or gaseous positive ions) by the Austrian Wien and of the electron by J. J. Thomson, an Englishman.

Each of these discoveries was fundamental to the work of the Manhattan Project. Which one would our pacifist scientists censor and who would accomplish the censorship?

Let us look further at the fundamental discoveries which followed. Marja Sklodowska Curie, a Polish graduate student, and Pierre Curie, her French husband, discovered the elements polonium and radium. Ernest Rutherford, a New Zealander working in Canada and later in England, unearthed a mass of information about radioactive elements and their decay in the first two decades of the present century. In 1919 he achieved the first successful transmutation—that of nitrogen into oxygen, discovered the proton, and set off a barrage of transmutation experiments in laboratories around the world.

Frederick Soddy of England introduced the isotope concept in 1911. Youthful Henry Moseley established the physical basis for atomic numbers before being sacrificed to military exigencies in the storming of Gallipoli in 1915.

In Germany Max Planck, studying heat radiation by a black body in 1900, abandoned classical ideas and advanced the quantum theory. Einstein bolstered the new theory in applying it to photoelectric effect and worked out the famous $E = mc^2$ formula for the equivalence of mass and energy at about the same time.

Niels Bohr, Danish student of Rutherford, in 1913 developed the theory of the structural atom, breaking sharply with classical theory to relate the spectral behavior of hydrogen to quantum considerations. The twenties saw further theoretical progress in the understanding of the atom through the concepts of the Englishman Dirac, the Frenchman de Broglie, and the Teutons Pauli, Schrödinger, and Heisenberg. The thirties saw the discovery of heavy hydrogen in America by Urey, the neutron in England by Chadwick, the positron in America by Anderson, artificial radioactivity in France by Madame Curie's daughter Irène and her husband Frédéric Joliot. They saw Lawrence develop the cyclotron at Berkeley. They saw Fermi of Italy bombard uranium with neutrons—Hahn and Strassman and Lise Meitner of Germany interpreting his experiments as the nuclear fission of U^{235}. Yes, the fundamental discoveries were in print by

1940 for the scientific world to read. Now where, may we ask, would the proponents of national security have stopped publication? One can see that science knows no national boundaries. Censorship by a single nation might safeguard for private use an occasional discovery, but it would not prevent the discovery from being soon made elsewhere. Only an international agreement among scientists could stop the flow of information. But what would be gained? The discoveries just enumerated led to the atom bomb with all its horrors and its fears and suspicions. But these discoveries also led to our understanding of modern chemistry and physics with their commercial applications. The availability of isotopes has led to the tagging of molecules which can then be followed through industrial processes or through metabolic processes. Through this the role of soil constituents in plant growth is better understood. The fate of fats, carbohydrates, proteins, salts, vitamins, hormones, and drugs is being revealed in the body through the use of tagged compounds. The radioactive atoms themselves offer hope of more effective treatment of devastating diseases. Atomic fission itself need not be an unmixed horror for it offers real possibilities as a useful energy source. No, we must not expect a momentary security if we stop publication of our discoveries. We do not have anywhere the omnipotence to decide when not to publish, where not to publish, what not to publish. Lacking this omnipotence, aren't we better off working in other directions to solve our problems without stifling future progress?

I turn next to what may be termed the *sociological area.* In the area of social relations the scientist is again in a position where he can make a contribution. Within his field of competence he has an obligation to work for the social good. I should like to discuss several specific instances that come to mind.

There is the problem of inter-group relationships. Anton J. Carlson, the renowned physiologist long at the University of Chicago has recently stated the case particularly well so I quote: "Factual, that is, scientific education on the nature of man seems necessary for the best future of man. Such education includes the scientific evidence of the unity of the human race. Despite so-called racial differences in such minor details as skin color, language, and religions, science has proved that the people now living on our earth are one species. This fact, understood and accepted by all sane citizens, should gradually eliminate racial prejudice, fear, and hate. It should promote cooperation in place of violence. Basic to the achievement of freedom from fear, want, and violence is the freedom to know."*

Then there is the conservation area. The scientist is in a good position to understand the cycles of nature and the effect of maladjustments in these cycles brought about by the improper use of resources. The proper functioning of nature requires a proper balance of animal and plant species, water, soil, and weather. Modern civilization has seriously strained this balance. We owe it to future generations to leave them a world where the strains have not been so severe that a decent civilization cannot continue.

Closely allied to the problem of resources is the problem of an optimum population. Within our own lifetimes, improvements in sanitation and medicine in the more advanced countries have brought about a significant increase in the life span. Coincident with this we can observe large areas of the world where the population pressures are such that whole populations are living in a state of chronic malnutrition. Shall the natural scientist close his eyes to this and say that it is the problem of the social scientist? Shall the social scientist insist that he must not be bothered since he is a pure scientist searching for natural laws? Or shall they join hands in grappling with the problem of the world's cultural unfortunates?

Speaking for myself, I feel that we must do the latter. Admittedly the problem is a sensitive one. Much can be accomplished by extending a knowledge of sanitation and agriculture as has been done in some countries by the Point 4 Program. However, the best efforts along medical lines and improvement of the food supply can come to nought if the populations of the undernourished areas continue to multiply like rabbits. Here we face religious and cultural taboos but they had better be faced honestly rather than trying to accomplish the impossible. As A. V. Hill recently said, "If they (representatives of religions) now claim that the facts and trends of overpopulation are not what we say, we can argue about that as a scientific question: but if they insist that its consequences should be left to God, they must allow us as citizens to take the opposite view."†

Finally, I would like to examine the scientists' obligations in the field of *education.*

First, there is an obligation to insist on sound scientific training for all. I do not mean that everyone should be trained as a scientist but that everyone should have an understanding of the problems of science and how such problems are attacked. There should be developed a faith in the unity of nature, a belief in the rational explanation of natural phenomena instead of a willingness to

* *Science,* **117,** 701 (1953).

† *Bull. Atomic Scientists,* **8,** 265 (1952).

accept supernatural answers. There should be an understanding of what is and what is not possible. There must be an understanding of the place of science in the modern world. We live in an age dominated by the discoveries of science. We must face the fact. The attainment of the bachelor's degree without a single credit in science, as was possible in my own university until a few years ago, is an intolerable situation in this day.

Second, there is an obligation to insist that the education of scientists, both pure and applied, be not so specialized that the trainee is incompetent to play a useful role outside his own narrow branch of training. There must be room in the science curriculum for a liberal sprinkling of such studies as will bring about the development of an educated man rather than merely the development of a competent technician. The scientist, in addition to being professionally competent, should be able to live a personally satisfying life and a socially useful life. A scientific education which fails to permit sufficient study of the humanities and the social studies is a fraud, just as a course stressing the humanities to the exclusion of the sciences is a fraud.

It seems to me that every curriculum in civil engineering ought to contain a generous sprinkling of courses in art, political science, and sociology—not just to provide breadth of education, but to add to professional competence. We should not be satisfied with the engineer who is capable of designing and building a durable bridge. We should also insist that he be able to build a bridge that is intrinsically beautiful and esthetically fitting to its environment. Further, it should be a socially integrated part of its community, meaning that it should be capable of fulfilling its role as a bridge without creating congestion, hazard, and inconvenience.

Finally, we should insist that education instill a love of truth, freedom, justice, and integrity that will stand as a bulwark against the anti-intellectualism which is rampant in this country today. We must build a people who demand fair play not only in athletics but in politics, in business, and in social relations. We must build a people who can recognize and expose quacks, faddists, self-seekers, and demagogues, not only in science but in other fields as well. But we must also be able to distinguish quackery from honest but different opinions. We must be willing to hear the honest minority.

In concluding, let me make the plea that we apply the findings of science to the elimination of the unpleasantness and drudgery of life, but let us use care that science remains our servant. It must not rob us of the opportunity to enjoy life to the fullest. There must remain in human life the opportunity for the expression of individual creativeness. If science ever suceeds in shoving the humanities into the background then man is headed for some such fate as Aldous Huxley pictured for him in his *Brave New World*. If, however, man can utilize the discoveries of science but still retain his individualism —and I use the word not in the sense of freedom to exploit his fellow men, but in the sense of living his own life and expressing his own creative talents —then we can look forward to the flowering of a civilization such as the world has never seen.

The Composition of Wines

MAYNARD A. AMERINE

The author is a graduate of and received his Ph.D. in plant physiology from the University of California. With the repeal of national prohibition he entered the field of enology—the study of wine. In addition to numerous reports on his researches, Professor Amerine has written several books. He is professor of enology at the University of California and is currently studying some biochemical aspects of wines in Spain and Germany on a Guggenheim grant.

WINE, a fermented beverage produced from grapes, is one of the oldest foods known to man. Every year nearly four billion gallons are produced. In all occidental countries it is a popular beverage, and in France, Italy, and Spain its production is a major factor in the national agricultural economy.

Many different types of wines are produced, depending on the variety of grapes, the climate of the region where the grapes are grown, the fermentation procedure, and the treatments given the wine during aging. But basically wines can be divided into two major categories, those to which no alcohol is added during or after fermentation, and those to which alcohol is added. The first group contains the table wines of 8 to 14 or 15 per cent alcohol, which, as their name implies, are intended for consumption with food. Wines of the second group, called dessert wines, are usually sweet, and a part of their alcohol (they usually contain 17 to 21 per cent) has been added to prevent fermentation of all the sugar.

Alcohol is not the only constituent of wine that has physiological interest. This review summarizes what scientists have learned about the composition of the common types of table and dessert wines. It deals with only the types commercially available in this country. Home-made and some minor foreign types fall outside the limits to be discussed here.

Sugars and Related Compounds

Grapes contain dextrose and levulose. During ripening the dextrose/levulose ratio decreases from 1.5 to about 1.0 or slightly less. Very little sucrose is found in European varieties of grapes—less than 1 per cent. During ripening the total sugar content increases rapidly; it should be between 20 and 23 per cent for table wines and 24 to 26 for dessert wines. In the eastern United States and the northern European countries grapes often fail to ripen adequately, and sucrose or invert sugar may be added. This is unnecessary in the Mediterranean countries and is illegal in California. In table wines practically all the sugar is fermented—usually dextrose slightly more rapidly than levulose—and normally less than 0.2 per cent remains in the finished product. There are two exceptions. A few sweet table wines are produced. These are sold as Sauternes (sauterne in California) or under other names. A second exception is the new, slightly sweet, red table wines now being prepared for the American market under various trade names. These contain about 1 per cent sugar. A third possible exception is the kosher-type wines that have become popular. They have the alcohol content of table wines (below 14 per cent), but are very sweet, containing up to 14 per cent sugar. They are really more of a dessert wine than a table wine. The reason for this is that sugars have a specific dampening effect on appetite. To drink sweet drinks before or during meals reduces appetite and thus interferes in that free selection of food which is the basis of a balanced diet. Dry table wines are thus the wine of choice with meals. Dessert wines contain more or less sugar depending on when the extra alcohol was added during fermentation.

Small amounts of pentose sugars, mainly arabinose and traces of xylose, are found in wines. Related compounds, such as rhamnose, pentosans, and methyl pentosans, and dihydroxymaleic acid are likewise reported. The pectin content of grapes is relatively small—less than 1 per cent—and this is reduced to negligible amounts in wines. Even so, the removal of pectins by means of added pectolytic enzymes often increases the clarity of new wines. Dextrins are reported in amounts of less than 0.1 per cent. Mannitol is found in some diseased wines.

Acids

Grapes contain relatively large amounts of tartaric and malic acids and a small amount of citric and tannic acids. Some varieties have a much higher acidity than others, even at the same stage of maturity. Grapes grown in warm regions always contain less acidity, at least of malic acid, than those grown in cold regions. The acids are of great importance in the fermentation, aging, and taste of the wine. Tartaric is considerably stronger than

malic acid. Table wines usually contain 0.5 to 1.0 per cent titratable acidity calculated as tartaric, while dessert wines contain 0.3 to 0.6 per cent. From 10 to 40 per cent of the acidity is due to malic acid. Only 0.01 to 0.05 per cent citric acid is found in wine.

Although the relationship is not direct, owing to the very good buffer capacity of musts and wines, high acid wines usually have a low pH. At the lower pH the fermentation is cleaner, color and flavor extraction are better, and clearer wines of better stability are produced. Wines of lower pH are also more resistant to bacterial attack; they have a brighter color and a fresher taste. The pH of table wines is usually from 3.0 to 3.5 and of dessert wines from 3.5 to 4.0.

During fermentation, succinic, lactic, acetic, and formic acids are produced, while the tartrate and malate contents decrease. The tartrate content decreases because of the insolubility of potassium acid tartrate in alcohol, while the malates are partially fermented. During aging, the malate may be attacked by certain microorganisms to produce lactic acid and carbon dioxide. Sparkling wines, of course, contain relatively large amounts of carbonic acid. Succinic acid is present in amounts of 0.05 to 0.20 per cent in table wines, depending on the amount of fermentation. Lactic acid varies from 0.03 to 0.40 per cent or more, depending on the amount formed in fermentation and the extent of the malolactic fermentation.

While only small amounts of acetic acid are formed during alcoholic fermentation—usually less than 0.02 per cent—various bacteria will produce much larger amounts during storage, particularly if the casks are not kept completely full. Spoilage actually appears to be due to ethyl acetate rather than to acetic acid, but the acetic acid content is usually taken as a measure of the spoilage. The present American limit for white table and dessert wines is only 0.120 g. per 100 ml., and 0.140 for red table.

To obtain the proper coolness for aging, the wine is often stored in caverns. The casks in the foreground are more than man sized. (Courtesy of Wine Institute.)

Formic acid is found in amounts of about 50 mg. per liter in sound wines and in higher quantities in spoiled wines. Butyric acid is reported in variable amounts, but the best results indicate only about 10 to 20 mg. per liter in sound wine. Glyoxylic acid is found in sound grapes and gluconic acid is reported in grapes attacked by certain molds.

Alcohols

The most important alcohol in wines, as in beer and whiskey, is ethyl. Wines contain from 8 to 24 per cent alcohol depending on the degree of maturity of the grapes, the amount of sugar added before fermentation, the amount of alcohol added during or after fermentation, and the losses occurring during fermentation and aging. Occasionally increases occur during aging when the container is stored under conditions of very low humidity. The factor for alcohol yield (by volume) from sugar according to the Gay-Lussac equation should be about 0.64, but Pasteur obtained only 0.611, and many studies report only 0.50 to 0.55. The intoxicating property of wines is due entirely to ethyl alcohol.

Very little methyl alcohol is found in grape wines. It is not produced by alcoholic fermentation or from glycine. Its sole source appears to be in the hydrolysis of pectins. Usually less than 0.15 per cent can be found in wines.

Likewise, only small amounts of the higher alcohols are found, but because of their pronounced odor they contribute to the quality of brandy and probably of wines. The main constituents of the higher alcohols are isoamyl, *n*-propyl, isobutyl, active amyl, *n*-butyl, and *sec*-butyl. Probably present also are *n*-hexyl, *n*-heptyl, and *sec*-nonyl. About 10 to 175 mg. per 100 ml. of wine have been reported, but the average is below 100 and in the better studies below 50. The higher alcohols are derived from deamination of amino acids, though it is reported that more higher alcohols are formed than can be accounted for by the decrease in amino acids. This may be because yeast proteins are decomposed. Contrary to popular belief, the higher alcohols are present in too small amounts to have a significant physiological effect.

A typical scene in the coastal wine section of California, showing the rolling hills, the well-groomed vineyard, and the patches of oak trees in the distance. The cultivation of these steep hills must be done by horses, and the ripe grapes are brought down to the winery on sleds. (Courtesy of Wine Institute.)

Glycerin, a polyhydric alcohol, is found in amounts of 0.5 to 1.5 per cent in wines. While it is the second most important product of fermentation, its exact genesis is not known, though it appears along with pyruvic acid during fermentation. Glycerin seems to impart smoothness to wines and may ameliorate the burning taste of alcohol. The amount of glycerin produced decreases at high fermentation temperatures, but contradictory results are reported in the literature. It has been questioned whether the low carbon dioxide tension in laboratory fermentations was not a cause of the low glycerin production. Glycerin production is higher when sulfur dioxide is present, but acetaldehyde retention is greater. The alcohol/glycerin ratio also varies considerably, depending on the yeast employed, the temperature of fermentation, etc.

A closely related compound, 2,3-butylene glycol, is also always produced during fermentation, but it is odorless and has little organoleptic importance. More is produced in commercial than in laboratory fermentations. From 0.01 to 0.15 per cent has been reported. The glycerin/2,3-butylene glycol ratio varies from about 4 to 15. Acetylmethylcarbinol is produced in amounts of only 1 to 30 mg. per liter in sound wines. Wine vinegar contains much higher amounts. Diacetyl has a pronounced odor and may be a minor factor in the quality of some red wines which contain 2 to 4 mg. per liter. Diacetyl can be detected by the olfactory nerve at about this concentration.

Aldehydes and Related Compounds

Acetaldehyde, a significant intermediary in alcoholic fermentation, is the most important aldehyde present in wine. Its accumulation is strongly inimical to the quality of table wines, but its presence in appreciable amounts in sherry is normal. Amounts of over 100 mg. per liter usually give table wines a vapid or oxidized taste, but 200 to 300 mg. per liter are not uncommon in some sherries. Traces of formaldehyde, propionaldehyde, cinnamaldehyde, oenanthaldehyde, vanillin, acetone, and methyl ethyl ketone are also reported.

Acetal is present in table wines in small amounts, 0 to only 6 or 7 mg. per liter. But in dessert wines up to 30 or 40 mg. per liter are reported. An accurate and simple procedure for acetal determination remains to be developed. It has a rather pleasant odor.

Hydroxymethylfurfural, a dehydration product of levulose, is formed in sweet wines that have been heated. Thus, madeira wines and California sherries, both of which are produced by heating sweet wines, contain appreciable amounts—30 to 300 mg. per liter. Wines made with grape concentrate contain hydroxymethylfurfural. Thus, a positive test for this substance in a wine indicates that it has been heated or that concentrate has been added to sweeten it. Its odor, however, is not unpleasant, and it is probably a desirable factor in the olfaction of some heated wines. Furfural certainly occurs in

brandy and probably in wines, at least in dessert wines. A less common constituent is acrolein. This is a product of bacterial spoilage of glycerin. In some cases it appears to react with tannins to give a bitter taste to red wines.

Esters

The importance of esters to the quality of wines has been greatly overemphasized in the literature. Actually, the only ester present in amounts large enough to influence the odor markedly appears to be ethyl acetate, and this has an objectionable acescent odor if over 150 mg. per liter are present.

There are reports from Russia that carbonic acid esters are important in the formation of the sparkling wine odor in sparkling wines. These studies have not been confirmed here and have been questioned there.

Esters of the acids previously reported, and valerianic, capronic, caprylic, caprinic, and pelargonic acids also occur, and possibly those of isobutyric, isovaleric, and oenanthic as well.

Polyhydroxyphenols

Tannins and coloring matter are the primary heterocyclic polyphenolic compounds present in wines. The tannins of wines are about equally *l*-gallocatechin and *d*-catechin. In white wines only about 0.01 per cent tannin material is found, but in red wines it may mount to 0.3 per cent. The tannins have a bitter taste, and one purpose of the aging period for red wines is to reduce the tannin content. Tannins have some antiseptic value, act as antioxidants, and form precipitates with aldehydes.

A mechanical crusher delicately separates the stems from the fresh grapes without breaking the seeds. After going through the crusher, the grapes and their juice, called "must," are pumped into large vats, where they are left to ferment. (Courtesy of Wine Institute.)

The color of red wines is due mainly to the monoglucoside oenin, but petunidin, delphinidin, and the diglucoside of oenin are also reported in *Vitis vinifera* grapes, and other anthocyanins are found in other species. Oenidin appears to be present in almost equal amounts with oenin. By heating and aging the anthocyanins are partially demethoxylated.

The color of red wines is very important to their quality, and much experimentation has been performed to extract the maximum color from the skins, to protect the color during aging, and to provide artificial colors. The anthocyanins act as acid-base indicators, and the red color is sharper and less blue at the lower pH's.

In white wines the flavonol pigments quercitrin and isoquercitrin have been reported.

Nitrogen

The total nitrogen content of wines is likewise very variable, varying from about 300 to 1200 mg. per liter. The ammonia fraction, 0 to 200 mg., is important as a specific catalyst in alcoholic fermentation. It is reduced to a negligible value during fermentation. The amino acids so far reported include alanine, arginine, asparatic acid, cystine, glutamic acid, glycine, histidine, isoleucine, leucine, lysine, methionine, proline, serine, threonine, tryptophane, tyrosine, valine, and phenylalanine. Glutamic acid was reported in amounts as high as 150 mg. per 100 ml., which seems high, as does the value of arginine of 110 mg. per 100 ml. Amino acids originate from grapes and yeast autolysis.

The presence of excessive amounts of nitrogenous substances, particularly of the amino acids, is favorable to spoilage of wines. Only small amounts of protein have been reported and these are precipitated by the alcohol. In certain seasons enough protein is present in the new wine to cause cloudiness when the temperature of the wine is raised.

Enzymes and Vitamins

Various enymes are present in wines in addition to those associated with the yeast cell and alcoholic fermentation. Polyphenol oxidase, catalase, esterase, invertase, and pectolytic and proteolytic enzymes are the most common. Oxidizing enzymes of the peroxidase type are also present. Polyphenol oxidase is, however, possibly the most important, as it causes the oxidation of polyphenols, which is the main reaction when grape juices exposed to the air

darken in color. Grapes attacked by various molds contain higher amounts than sound grapes.

Ascorbic acid is present in small amounts in fresh grapes (1 to 18 mg. per 100 ml.), where it is an important factor in the reducing system of the must; only negligible amounts are found in wines.

Vitamin A is likewise present in negligible amounts. But thiamin is found in amounts of 0 to 50 μg. per 100 g. of wine. Riboflavin occurs in amounts of 5 to 120 μg. per 100 g. About 70 μg. of pyridoxin, 65–120 μg. of nicotinic acid, and 70–140 μg. of pantothenic acid are also reported. In addition, *p*-aminobenzoic acid, biotin, and inositol occur, the latter in appreciable amounts.

Aroma

Most important to the quality of wines is their odor. A few varieties of grapes, muscats for example, give a characteristic odor to the wine, and this is probably due to some specific compound or group of compounds. The Concord-flavor of some varieties of grapes grown in the eastern United States is apparently due primarily to methyl anthranilate.

The winelike odor of wine is due mainly to lauric acid, even though only a few parts per million are present. The roselike odor of certain wines has been attributed to *p*-hydroxyphenylethyl alcohol, which may be derived from the amino acid phenylamine. A terpene, α-terpineol, also occurs.

Actually, the odor of wines is an extremely complex blending of a great many compounds, none of which is present in large amounts. In addition, the volatility of ethyl alcohol and the solubility in it of the various odorous constituents probably markedly influence the odor. The acidity, temperature, and amount present are also important factors. It should be noted that the odor of many of the substances mentioned is very different at low concentrations than at high.

Inorganic Components

The ash content of wines varies from 1.1 to 5.2 g. per 100 ml., averaging about 2.5. The most important anions found are chloride, phosphate, silicate and sulfate. The phosphate, of course, is a significant factor in fermentation. The main cations are calcium, magnesium, potassium and sodium but traces of many other elements can be detected. As little as 1 mg. per liter of copper may influence the clarity of a white wine. The potassium content is far greater than that of the other minerals.

The various steps in champagne corking are shown in this picture from the early 1870's. In the shed were carried on the processes of disgorging, perfecting the fill, and recorking. The finished champagne, corked and labeled was packed in the handwoven baskets, ready for market. (Courtesy of Wine Institute.)

The New Orleans Academy of Sciences: Its First Hundred Years (1853-1953)

KARLEM RIESS

A native of New Orleans, Karlem Riess completed work for his B.S. and M.S. at Tulane University, and received his Ph.D. from Brown University in 1943. At present he is associate professor of physics at Tulane University. He has been president of the Tulane chapters of Phi Beta Kappa and Sigma Xi, and is now president of the New Orleans Academy of Sciences.

THE Old South in the period just before the Civil War has been presented by most historians as an agricultural society, with its accompanying system of slavery. Industry was practically nonexistent. Science and technology were insufficiently organized to exert a significant effect on the social pattern. There were, however, a large number of individuals genuinely interested in science. They were scattered throughout all the southern states and made substantial contributions to knowledge through their writings, experiments, and lectures.

The citizens of New Orleans, largest and most cosmopolitan city in the South during this period, were particularly interested in all types of science. A Physico-Medical Society was organized as early as 1820, and in 1839 the Louisiana Medico-Chirurgical Society was founded. These two, primarily for physicians, did admit as "assessors" or associate members persons scientifically inclined but without a medical degree. Assessors of the Physico-Medical Society were drawn from all professions, but those of the Medico-Chirurgical Society were limited to allied professions such as chemistry or pharmacology. Traveling lecturers, men of such caliber as Benjamin Silliman and Louis Agassiz, attracted large, enthusiastic audiences. One of the contemporary journals reported that there could be no complaint

> . . . that the money-making, money-spending, amusement-seeking citizens of New Orleans do not appreciate him [Agassiz] seeing that among his auditors are not only hundreds of learned lawyers, physicians and teachers, but hundreds of merchants and still other hundreds of the fair sex.

Benjamin Silliman, Jr.'s New Orleans lectures (1845) on agricultural chemistry are believed to have been the first of their kind given in the United States.

In 1834 a group of young, alert physicians organized the Medical College of Louisiana. The college was merged with the University of Louisiana in 1847, and is now the School of Medicine of Tulane University. The philosophy of the early New Orleans scientists was stated by Dr. Thomas Hunt, founder and first dean of the Medical College of Louisiana, in his initial lecture (1835):

> There is no mystery about science. Truth is simple and reveals her doctrines in a language intelligible to every mind. She affects no air of pedantry, and decrees it inconsistent with her vocation to annoy and perplex the learner with far-fetched and uncouth terms. To my mind, there is a moral sublimity in the picture of a learned and philanthropic man, conveying the lessons of wisdom and experience, in the beautiful language of simplicity, to an acquiring and intelligent student.

These physicians were not merely men of medicine; they possessed wide scientific interests in unrelated fields such as botany and geology. They met almost daily and discussed their work and reading. Thus it is not surprising that among these physicians were several charter members of the American Medical Association and of the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, and, in 1849, leaders in the formation of a Louisiana State Medical Society.

It was in such a scientific environment that the New Orleans Academy of Sciences was formed. On the twenty-first of March, 1853, five New Orleans physicians—Doctors Bennet Dowler, Noah B. Benedict, Howard Smith, Joseph S. Copes, and Henry D. Baldwin—met at the home of Dr. Copes, "to

confer upon the expediency of some kind of organization with a view to mutual improvement in medical and natural sciences." With Dr. Dowler in the chair, and Dr. Copes as secretary, they outlined a Constitution and By-Laws for the incorporation of a society to be devoted to the cultivation of medicine and natural sciences, with the power to establish lectureships and professorships. The five physicians agreed that their number should be expanded immediately and invited eight men to their second meeting. After five preliminary meetings, each time adding associates, formal organization was completed on April 25, 1853, with the adoption of the Constitution and By-Laws. Twenty-seven men were listed as founders, including thirteen physicians, two pharmacists, three university professors, three engineers, three ministers, one lawyer, one high school principal, and one chemist. Of the twenty-seven men, at least two were nationally known in their fields, Dr. Bennet Dowler (physiology) and Dr. John Leonard Riddell (chemistry, botany, and medicine). In subsequent years at least ten more of these men achieved noteworthy success. The Academy was not formally incorporated until 1856. Curiously, it was not learned until 1936 that the Act of Incorporation was not attested to by the Attorney General of Louisiana, a requirement in 1856. Thus for eighty years the Academy was not a legal corporation. This was corrected by reincorporation in 1939.

Membership was limited to persons who had given proof of their devotion to science by the production of a paper on a scientific subject. Election was by unanimous vote of the members, using a white- and black-ball system. The wording of these provisions resembles those in the constitutions of our social fraternities and Masonic organizations. The Constitution and By-Laws passed through many inevitable revisions, but the unanimous vote provision remained until the affiliation of the Academy with the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE in 1919.

The original Constitution termed the active members "fellows" and provided for the election of distinguished scientists as honorary members. A third class of membership, corresponding members, was soon added. In the first two decades of the Academy many corresponding members, but only six honorary members, were elected. The honorary members were Joseph Henry, Louis Agassiz, A. D. Bache, Baron von Humboldt, Lt. Matthew F. Maury, and Dr. E. K. Kane.

One of the first acts of the new society was to correspond with Joseph Henry, then secretary of the Smithsonian Institution. Henry expressed personal sympathy and promised "the hearty cooperation of the Institution in any project" for the promotion of natural history in New Orleans.

The first scientific session was held on March 28, 1853—a discussion based on specimens of cypress and iron brought to the meeting by Dr. Dowler from excavations in the suburbs of the city. The first two formal papers were presented on April 11, 1853. One was by Dr. Josiah Hale on the history of botany and classification schemes, the other by Dr. Bennet Dowler on the natural history of the mosquito. The Academy was organized into ten scientific sections: (1) Natural History of Animals; (2) Botany; (3) Geology and Mineralogy; (4) Chemistry and Natural Philosophy; (5) Astronomy and Mathematics; (6) Antiquarian Researches and Ethnology; (7) History and Biography; (8) Medicine and Physiology; (9) Geography, Statistics, and Political Economy; (10) Psychology and Aesthetics. The fellows of the Academy were permitted to affiliate with as many sections as they were interested in. Chairmen of the sections were chosen by ballot.

The early meetings of the New Orleans Academy must have been lively and stimulating sessions. The minutes contain references to many excellent papers and record pages of discussion of these papers. Unfortunately very few of the manuscripts exist today. By agreement, politics and religion were excluded from all discussions. Weekly meetings were held from September until July. Recess during the summer months was prompted by the prevalence of yellow fever.

The library and museum of the Academy were important adjuncts and developed into extensive collections. At each meeting donations of books and specimens were received and listed in the minutes. These donations came from many non-members as well as from the members themselves. The ravages of occupation troops during the Civil War and many moves from one location to another resulted in the loss of many of the original documents, books, and specimens.

The Academy accomplished a number of interesting things during its early years. Academy members, in cooperation with the Common Council of the City of New Orleans, supervised the drilling of an artesian well in the center of the business district of the city, making analyses of the borings and the water each day. The Academy urged the Legislature of the State of Louisiana to make a complete scientific survey of the State, with the Academy as director. The Academy took the initiative in arousing public interest for proper protection of the City of New Orleans against flood waters of the

Mississippi River by advocating a system of protection levees and drainage canals. Academy members kept accurate daily meteorological records for many years. And not the least important contributions were the individual researches of the members, as indicated by papers presented before the Academy and later published in national and local journals.

In 1860, by action of the Legislature, the Academy was affiliated with the University of Louisiana as its Department of Natural Sciences. The Academy wanted this affiliation so that permanent meeting rooms and museum space in the University buildings would be available. In return for these privileges the members of the Academy gave courses of lectures and allowed the students and faculty to use the library and museum. This arrangement did not prove to be a happy one. The Academy was well satisfied, but the University authorities resented the intruders. The feuding continued for about fifteen years. On several occasions attempts were made to evict the Academy. In 1880 the library and all collections were moved into a corridor and the rooms declared vacated. This finally forced the Academy to move to other quarters.

The Civil War had its effect on Academy activities as on all activities in the South. Meetings were suspended from 1861 to 1866, except for a few scattered gatherings. But, as one of the local historians wrote,

> . . . the Academy, not without much struggling . . . soon reestablished itself in its efforts and regained its former position without any outside aid whatever.

In the post-Civil War period the number of scientific sections was increased to twenty-one, essentially a section for each subdivision of the principal sciences. The Academy offered its first research grants in 1872—prizes for the best collections and descriptions of the entomology of Louisiana. These were given wide publicity, and evoked much public interest. The status of the Academy in this period (1872) is best summarized by its president, Dr. Joseph S. Copes, who wrote of the

> . . . continued and vigorous existence [of the Academy] notwithstanding the many adversities it has met; and upon the straightforward integrity it has always maintained in the face either of bitter and inflated enmity or of designing and spurious friendship.

Its library and museum

> . . . also created a taste and predilection for scientific studies and pursuits in our midst, and has bestowed encouragement and assistance upon those who have been disposed to undertake the study of nature or to collect for examination the rarer specimens of her handiwork.

The Louisiana Legislature of 1871 appropriated five thousand dollars to the Academy for explorations of the geological, agricultural, and hydrodynamic conditions and resources of the state. This grant was vetoed by the governor of the state, for the reason that the Academy was not under state control, noting that state funds could only be allotted to organizations under its control.

During the 1870's John Tyndall was elected an honorary member and many foreign scientists were added to the list of corresponding members. In this period the first women became associated with the Academy as corresponding members. No women were admitted as active members until 1912.

The second important era in Academy history was from 1885 to 1890. The membership was substantially increased during these years, and many notable papers were presented and published. Meetings were held monthly instead of weekly. The members in 1885 proved to be a very discerning group. They revised the Constitution and By-Laws to provide for election of members distinguished in the arts and literature as well as those primarily interested in science. The newly established Tulane University, which had been formed from the University of Louisiana in 1884, had an exceptional faculty, headed by William Preston Johnston as president. Johnston, Florian Cajori, Brown Ayres, Alcee Fortier, R. H. Jesse, J. M. Ordway, Robert Sharp, Hanno Deiler, Dr. Joseph Jones, Dr. C. E. Kells, Dr. Stanford Chaille, and others became Academy members. The Academy and its library returned to the University buildings. The museum was abandoned and all remaining specimens were given to the museum of Tulane University. The number of scientific sections was reduced to three: Section A, mathematics, physics, astronomy, geodesy, and mechanical science; Section B, chemistry, mineralogy, geology, geography, archaeology, biology, histology, and microscopy; Section C, linguistics, history, political science, metaphysics, philosophy, anthropology, ethnology, economic science, and statistics. The absence of medicine and botany will be noted, particularly since these were prominent in the original Academy.

There was a lapse of interest in the Academy from about 1895 to 1912. The reasons for this are not known. There is no record of much organized activity, although occasional meetings were held. After a reorganization in 1912, monthly meetings were held with regularity until 1917. Many original scientific papers were presented. Throughout the years of World War I meetings were infrequent. The library was maintained on the Tulane University campus and expanded annually. The meetings

during this period tended to be more popular in character, covering such topics as the cattle tick and its control in Louisiana, hay fever control and prevention, control and eradication of the cottony cushion scale, and control of the Argentine ant in New Orleans. The Academy sponsored public control campaigns against the cottony cushion scale, camphor tree scale, and Argentine ant, with noteworthy success. The cooperation of the local newspapers and of municipal and state agencies was particularly good in these instances, with results of great benefit to New Orleans. Similar campaigns against the cattle tick and against weeds associated with hay fever were not as successful.

The Academy was affiliated with the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE in 1919, and has participated in the affairs of that group through its representatives at the Academy conferences and at the annual meetings of the AAAS. The affiliation proved to be a turning point in the life of the Academy, a turn in the wrong direction because many of the members stopped paying dues when the AAAS contributions to the Academy were received.

There was another period of decreased activity and a consequent drop in membership between 1920 and 1930. This resulted in a formal reorganization in 1933. A new Constitution and By-Laws were adopted, changing the financial basis of operation of the Academy by reducing the dues and initiation fees. The membership was increased and was quintupled within a few years. Monthly lecture meetings were resumed, many with visiting speakers brought to New Orleans for the occasion. The Academy also sponsored a series of radio programs.

There was also a general change in the perspective of the Academy. The organization matured, as Dr. E. C. Faust stated, from one

> . . . jealous of the activities of younger scientific groups in the City of New Orleans to the more logical position of coordinator and cosponsor in scientific activities and projects. Thus it has succeeded in bringing together scientific men in federal, state, institutional and private capacities, without overdominating the individual research groups.

In 1920 Dr. Reginald S. Cocks, Secretary of the Academy and Professor of Botany at Tulane University, suggested that the Academy sponsor the establishment of an arboretum and botanical garden in one of the parks of New Orleans. The suggestion furnished a lively issue for almost twenty years. The many committees which considered the suggestion were faced with apathetic public officials, insufficient funds, and a marked hostility on the part of the officials because an outside organization was attempting to aid in the administration of a part of the municipal property under their jurisdiction. The plan finally crystallized into a proposal to establish an arboretum and botanical garden, primarily containing tropical and subtropical plants, in the new addition to the New Orleans City Park, an undeveloped section (at that time), with the Academy as one of the sponsors. A booklet emphasizing the need for the arboretum and botanical garden was published by the Academy. The material result of all the discussions was the dedication of a tract in City Park for the project, and subsequent building of roads, lagoons and bridges, and filling, grading and planting of the area with over four thousand shade trees. The botanical garden was not established, since, as one of the committees stated,

> . . . botanical gardens are the product of a certain stage of social development which has not quite been reached here.

The arboretum was not in the form desired by the Academy nor was the Academy permitted to be a legal sponsor. The Academy served principally as a coordinator between state and municipal officials and the interested civic groups, such as the Southern Forest Experiment Station, Tulane University, and the various garden clubs.

A beneficial result of these arboretum discussions was the drawing up of a new charter and Act of Incorporation for the Academy. The legal procedure involved in revising the Constitution and charter occupied many business meetings, but the results have proved very beneficial to the Academy.

One feature of the revised Constitution is worthy of note. It restricts the election of honorary members to those active members who have served the Academy in a distinguished, unselfish fashion. Since the abolition of the class of corresponding members, the active membership in the Academy has been open to scientific men and women from all states, and associate membership to nonscientists.

One of the important activities begun during this period was the Junior Academy of Sciences. The original proposal was for a junior section of the Academy, with membership composed of high school, normal school, and college students. However, the intricacies of internal politics produced a different sort of Junior Academy, a section composed of science teachers in the New Orleans high schools as representatives of individual science clubs within the schools. The initial response on the part of the science teachers was far from satisfactory. This rather peculiar type of Junior Academy sponsored annually a single demonstration lecture for high school students and a seminar for teachers, but

that was all. The late Dr. Otis W. Caldwell, on a visit to the New Orleans Academy in 1936, was amazed at this situation, and indicated it was the only Junior Academy in the United States without any junior members. Through the persistent efforts of one of the energetic officers of the Academy the situation was changed, and a Junior Academy composed only of high school students was formed. The sponsorship of the juniors is one of the major functions of the New Orleans Academy today. A member of the senior Academy serves as advisor and aids in the planning of programs, but the officers and committee members are all high school students. An exhibit of projects and a program of papers by the juniors is a feature of each year.

The first research grant jointly sponsored by the American Association for the Advancement of Science and the New Orleans Academy was awarded in 1936 to Dr. Howard R. Mahorner for a study of the experimental production and the causes of goiter. Similar grants have been awarded annually since that time, resulting in the publication of some important papers. The recipients represent all fields of science.

In recent years the Academy has held monthly or semimonthly meetings, with an annual meeting in the spring of the year. The monthly meetings are public lectures, discussions, or laboratory field trips, usually of a semipopular nature. The annual meetings and special symposia are devoted to more serious and more technical subjects. The Academy has been fortunate to be able to arrange frequent joint meetings with many of the other scientific societies in New Orleans. On three occasions annual meetings have been held in conjunction with the Louisiana Academy of Sciences. Some of the annual meetings have been divided into sections, with a series of short papers and one feature paper at each session. On other occasions a single session has been held, with a symposium or set of featured speakers following the Academy's annual dinner.

One of the annual programs is the presentation of research papers by graduate and undergraduate students from the universities in the vicinity. These are always stimulating meetings for the regular members as well as for the many students who attend. Recent civic projects include active leadership in the antirabies and rat eradication campaigns in New Orleans.

The Academy has not maintained a very active publication program. The first *Proceedings* of the Academy were issued in 1854, but no subsequent issues appeared. Printed Constitutions and By-Laws appeared in 1854, 1859, 1871, 1885, 1913, and 1919. Since that time the Constitutions have been mimeographed for distribution. Abstracts of the programs presented at the annual meetings have been published, as well as programs for the meetings themselves.

The library of the Academy has been deposited with the Howard-Tilton Memorial Library of Tulane University. The volumes are cataloged separately and are on separate shelves. Exchanges with foreign and domestic academies and other scientific bodies are maintained, with the librarian of the Howard-Tilton Memorial Library serving as curator (librarian) of the Academy. The archives, including the original minute books and similar items, are also deposited in the Howard-Tilton Memorial Library.

There are some who believe that in a modern metropolitan society there is no place for an Academy of Sciences, and who feel that the New Orleans Academy of Sciences and all similar organizations have outlived their usefulness. Yet, as we look back over the first century of its activity, it is apparent that the New Orleans Academy has fulfilled the aims of its founders and is continuing to do so. It has emerged as the sponsor of an extremely live and successful Junior Academy. It stimulates research through its scientific programs and research grants and it serves as a scientific coordinating agency in New Orleans. Thus we start our second century with faith in our Academy and hope for the future.

Archaeological Occurrences of Pronghorn Antelope, Bison, and Horse in the Columbia Plateau*

DOUGLAS OSBORNE

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SINCE 1947 there have been extensive but often unprogrammed archaeological excavations, testings, and surveys in the area known to physiographers as the Columbia Intermontane Province[1] and to anthropologists simply as the Plateau.[2] It is probably safe to say that nearly all this work has been either stimulated by or supported by the federal government's projected dams on the Columbia or on its tributaries. The famous Grand Coulee Dam and Reservoir, built by the Bureau of Reclamation, Department of the Interior, was the first of many that have been completed or are in construction or in planning stages by the Bureau or by the U.S. Army Corps of Engineers. Realizations of regional needs in the categories of flood control, electric power, and irrigation potentialities come nearer as each dam is completed.

It was recognized that there was a federal responsibility for the salvage of the scientific and cultural values that would be covered or obscured by the large reservoirs behind the dams. To the Smithsonian Institution was entrusted the responsibility for the organization of facilities and personnel capable of studying and publishing on archaeological, historical, and paleontological sites which were within the flood lines of the reservoir areas. Appropriations for the work have never been sufficient, but excellent administration of the funds and close cooperation between the National Park Service, the Smithsonian Institution, and local institutions has resulted in the amassing of a large amount of archaeological data. Much of this information has not yet been assimilated.

Thus far, most of our archaeological excavation has been in the McNary Reservoir, on the Columbia, from Umatilla, Oregon, to above Pasco, Washington, and in the Chief Joseph Reservoir in Southern Okanogan County, Washington.[3] A site near Trinidad (Potholes site) supplies the only data between the southeast central (McNary) and the northeast central (Chief Joseph Reservoir plus a cave site, 45-GR-2, near Grand Coulee) concentrations of activity. A large share of the work done in both of the reservoirs was either superintended or directed by the writer, who was on the Smithsonian staff during the periods when these sites were investigated.

A by no means unimportant aspect of the study of a defunct culture by a modern archaeologist is that of the economy, the method of gaining a livelihood that was practiced by the inhabitants. Such a study often becomes largely ecologic. Plant and animal life of an area, at various time periods, becomes of direct interest to the archaeologist's generally culturologic studies. Hence, all remains of plants or animals found in archaeological deposits are saved and data concerning them are recorded. The archaeologist of course takes these remains to a specialist for identification. The bones in the

* Permission to use herein the data derived from Smithsonian Institution River Basin Surveys fieldwork has been granted by Dr. Frank H. H. Roberts, Jr., Director, River Basin Surveys.

following lists have been largely fragmented by the Indians for the marrow.

Status of the Problem

This paper was prompted primarily by two references: Tipper *et al.*,[4] and Dalquest.[5] The first of these describes a bison (*Bison bison bison*) skull found in Whitman County, Washington; it mentions a few of the finds of fossil bison in the region and then, in a short discussion of the range of the animal, makes the incorrect statement that bison have not been reported in Washington in historic times. Dalquest mentions this mammal as a probable casual within the state. Haines[6] and Kingston[7] have both covered the question of the buffalo in the Pacific Northwest thoroughly. The paper of the latter probably contains nearly all the references to the buffalo that appear in early writings. Both authors find evidence of bison in eastern Washington in historic times.

Dalquest[5] discusses briefly the possibility that the antelope (*Antilocapra americana*) was an early native of the plains of eastern Washington. He concludes, in effect, that the animal should have existed there but states that he is unable to offer the necessary documentary or osteological evidences to clinch the point. Einarsen[8] indicates that the southern half of eastern Washington was occupied by the pronghorn at the "greatest extent of range." He does not, however, document this statement, and I am in no position to judge the validity of its foundation. It is my belief that recent archaeology has supplied information that will be of interest to all persons concerned with the above questions. Data on horse finds in Indian sites have been included as an addition to the body of dated information on the spread of that animal from the American Southwest.[9]

Roe's excellent monograph[10] on the buffalo gives a most cursory treatment of that mammal's range in this area. To his work must be added the compilations of Haines[6] and Kingston,[7] the ethnographic material from California,[11] and my data.

The Finds*

Raw data on the bones of the three mammals of interest here are given below, site by site. Distributions are plotted on Fig. 1. No attempt is made to show relative quantity on this map. It is doubtful if our information is sufficient to support any statements that rest upon quantitative or percentile comparisons.

45-BN-3.† This was the first site excavated by the Smithsonian Institution, River Basin Surveys, on the Columbia. It is in Umatilla tribal country, on the north bank of the Columbia about five miles above the Umatilla confluence. The site was important; over fifty burials were removed and large areas of moderately good midden were investigated. The dig was 50 by 150 feet. By far the greater area of the site was occupied, and a large number of the burials were made, in historic times. Trade goods, glass beads, copper ornaments, and scraps of iron were found in the midden and in the graves. Horse bones were not rare. The offerings of traders via native trade channels were commonplace in the area long before posts were established anywhere in the Columbia valley. Lewis and Clark certainly did not record the site.[12] With these data in mind, the site has been placed in the middle and late eighteenth century.

Antelope: no bones positively identified as antelope were found. Three bones, all somewhat the worse for wear, were labeled "deer or antelope" by Dr. White, who handled the material from this site: 1 radius, 1 distal humerus, 1 calcaneum, all from midden in both deep and shallow levels.

Bison: from the midden, middle depths: 1 cervical neural arch.

Horse: bones of horses were almost commonplace: 6 otoliths, 2 cannon-bones, 5 or 6 foot bones, 1 hoof fragment, 1 calcaneum, 1 astragalus, 1 metapodial, 1 axis, and numerous teeth.

Most sections of the site that yielded animal bones, had horse bones. They were found in all levels. The conclusion is inescapable that trade material and horses were present through much of the life of the site. Here antelope are doubtful,

* The identifications that form the basis for this paper were done by Dr. Theodore White, Smithsonian Institution, River Basin Surveys, and by Arthur Freed, Department of Anthropology, University of California. The expenses of the work done by Mr. Freed were defrayed by a grant from the Initiative 171 Fund for Biological Research of the University of Washington. Martha Flahaut, Curator of Biology, Washington State Museum, has advised during the preparation of the paper. Drs. White and Roberts have criticized an earlier draft.

Data are drawn from nineteen archaeological sites:

† The number designations for archaeological sites are those used by the Smithsonian Institution, River Basin Surveys. The first element, 45, is the State of Washington, forty-fifth in an alphabetical listing of the states. BN is an abbreviation for Benton County; 3 is a simple sequence or find number. This method of site designation, or variants, is widely used throughout the country.

ten of these were excavated under Smithsonian Institution direction; three were under National Park Service contracts with the University of Washington; three were by the University of Washington; one was made by that University in the 1920's; two were surveyed only by the University, and data from one are drawn from a published source. A grant from the Agnes Anderson Fund defrayed the expenses of an archaeological survey that gathered surface data from the two sites pertinent to this paper.

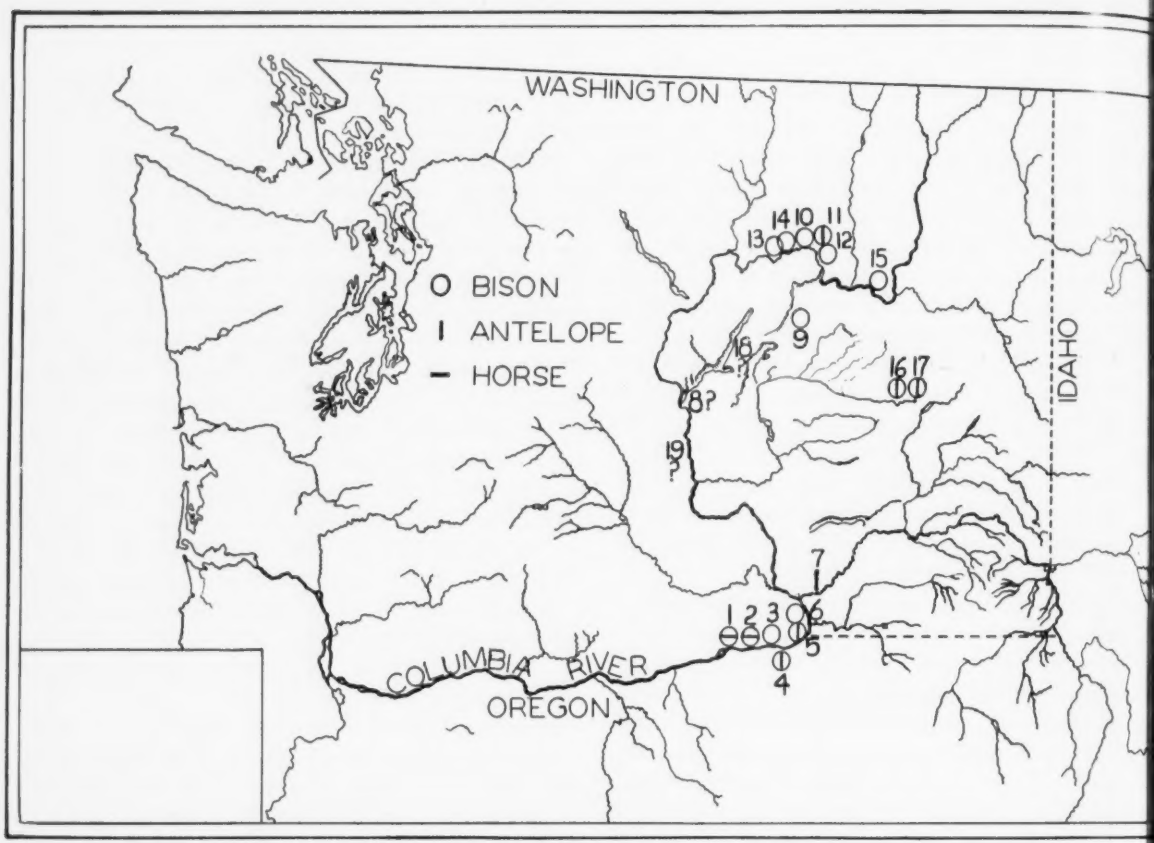

FIG. 1. Archaeological sites and mammal bones.

1. 45-BN-3, Late site; deer or antelope?, bison, horse
2. 45-BN-6, Late site; bison, horse
3. 45-BN-53, Prehistoric; bison
4. 35-UM-17, Prehistoric; antelope, bison (Oregon)
5. 45-BN-16, Prehistoric; antelope, bison
6. 45-BN-15, Prehistoric; bison
7. 45-FR-5, Prehistoric; antelope
8. Potholes site, Late; antelope?
9. 45-GR-2, Prehistoric; bison
10. 45-OK-10, Late; bison
11. 45-OK-5, Prehistoric; antelope, bison
12. 45-OK-2, Late; bison
13. 45-OK-11, Prehistoric; bison
14. 45-OK-12, Prehistoric; bison
15. Collier, *et al.*, 1942, site 11, Prehistoric; bison
16. 45-LN-3, Prehistoric; antelope, bison
17. 45-LN-1, Prehistoric; antelope, bison
18. 45-DO-3, Not excavated; deer or antelope?
19. 45-KI-18, Not excavated; deer or antelope?

bison *ca.* 0.017 per cent, and horse *ca.* 10 per cent.

45-BN-6. This, another late site, is five miles beyond BN-3, upstream on the same bank. Sixty housepits and a few rock piles, possible cairns, are scattered for nearly half a mile along a low flat terrace which varies from 4 to 12 feet above the Columbia. Most of the housepits are concentrated at the downstream end. Only four were excavated. BN-6 is probably one of the most recent villages worked by archaeologists in the area. Much in the way of traded material was found; even a bit of canvas was recovered from one housepit. A reference indicates that the site is to be identified with one noted in 1812.[13]

Antelope: no bones.

Bison:

Housepit 5, in central, trenched, part of housepit at 1.5–2.0 feet from surface: 5 ribs; at 2.0–3.0 feet from surface, 11 articulated dorsal vertebrae, 1 phalanx.

Housepit 6, at 1.0–1.5 feet from surface: 1 scapula, 1 phalanx.

Housepit 7, at 1.5–2.0 feet: 1 patella, 1 mandible; at 1.5–1.7 feet: 1 metapodial.

Horse:

Housepit 5, at 0.5 foot below surface: 1 radioulna, 1 metapodial.

Housepit 6, no location: 1 metapodial.

Housepit 7, 1.0–1.5 feet from surface: 1 skull fragment.

Housepit 59, at 0.5–1.0 foot from surface: 1 femur.

Test pit 1, in thin midden near river bank, no depth recorded: 2 radioulnae, 1 metapodial.

At BN-6, bison bones constituted 26 per cent, and horse bones about 12 per cent, of the mammalian remains.

45-BN-53. This is a large housepit village site; 183 pits were mapped. It lies between 45-BN-6 and BN-3. Only seven housepits of the large total were adequately investigated. No trade items were found in either the excavations or on the surface, with the sole exception of two glass beads found near the river's edge. The large site is thus before contact:* early eighteenth century, at the very latest. It is probable that the people who lived at BN-53 abandoned that site shortly before contact and began to live, while in their seasonal, semi-permanent, shallow pit houses, at BN-6, a few miles upstream. It will be recalled that this latter site had a contact occupation.

Antelope: no bones.

Bison: *Housepit 45,* lower levels: 1 radius, several cervical vertebrae.

Horse: no bones (as is usual for precontact occupations).

Here, the bison bones were a minor percentage of all mammalian bones.

35-UM-17. This island site is in the state of Oregon, Umatilla County. It is near Cold Springs, some thirteen water-miles above Umatilla, Oregon. Excavations were largely confined to trenching and excavating of the more promising of the nineteen housepits that comprised the site. In all, four were examined. The island is in Walula or Umatilla territory, the site precontact.

Antelope:

Housepit 15, at depth of *ca.* 2 feet in an area of bone disposal, 2.0–2.5 feet below surface: 1 mandible.

Bison:

Housepit 15, 2.0–3.0 feet below surface: 1 metapodial.

Housepit 14, 4.0–4.5 feet below surface: 4 phalanges.

Horse: no bones.

Of the bones found here, 2 per cent were bison and 4 per cent were antelope.

45-BN-16: This group covers the occupations of an entire island—Goat Island in the Columbia about six miles south of the Snake confluence in Benton County. Unfortunately, in spite of extensive prospecting, no deposits worthy of full-fledged excavations were found. One burial turned up; numerous test pits and clearings of debris were made, but thin or nearly sterile deposits led us to abandon the work there. Like FR-5, this site is in Walula tribal country. It is not possible to place the whole site or sections of it chronologically, but the areas excavated were prehistoric.

Antelope(?): test pit 1A, in level 1.0–2.0 feet: 1 distal metatarsal.

Bison: test pit 1, 0–1.0 foot: 1 head of femur.

Antelope bones form 4 per cent and those of bison form 4 per cent of the nonhuman mammalian remains from this site.

45-BN-15. This site, or more properly, group of sites, is on Rabbit Island immediately upstream from the Goat Island of BN-16. Like the latter, collectors have ravaged most of the better archaeological manifestations, with one exception. This is a series of burials protected by their greater than average depth. The deeper burials were found by the archaeologist while working out some more superficial ones. There thus is a burial sequence here. The artifacts found with the older burials, which were interred extended, differed from those found with the later, flexed or folded inhumations. Thus far, twenty-six burials have been found. The site bids fair to be an important one. Neither houses nor full-fledged midden was found on the island; no trade goods occurred.

Antelope: no bones.

Deer or antelope: midden, 42 inches deep: 1 right distal humerus.

Bison: from midden: 1 tibia.

Horse: no bones.

45-FR-5. A large housepit site, 45-FR-5, is on Strawberry Island, eight miles up the Snake River from its confluence with the Columbia. There are at least 131 housepits near the head of the island. They are saucer-shaped, rimmed depressions varying from 15 to 54 feet in diameter and from 0.3 to 2.9 feet in depth. No large midden deposits or burials were found on the island. All the animal bones studied were found in the small midden accumulations in the four housepits that were partly excavated or tested. Judging from the excavation and surface gleanings, FR-5 is wholly prehistoric. This observation may not be correct, but there can be no doubt that the housepits dug were occupied before trade goods entered the area or before they became an important aspect of local culture. This would place the site, or at least such of the widely scattered pits as were dug, at not later than the early eighteenth century. Lewis and Clark, who traveled in the area in 1804 and 1805, mention no occupation of the island.[12] No horse bones, also a good criterion of recency, were taken from the site. Haines suggests 1720–30 as the date for the

* "Contact" is a term used to designate that period when the Indian made face-to-face contact with the white man and during which trade objects and immaterial aspects of European-American culture began lively diffusion to the natives.

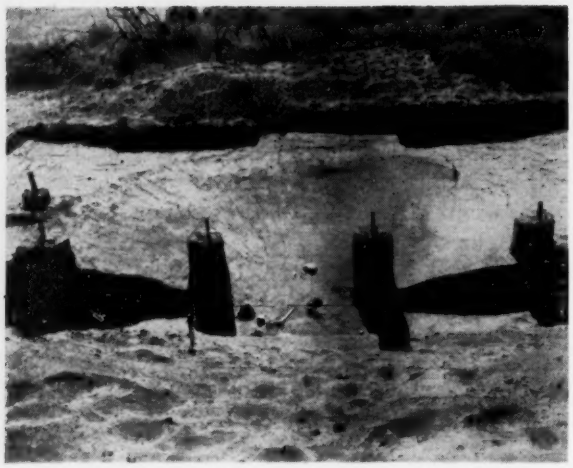

FIG. 2. Bison radius and cervical vertebrae near the fire area, main "floor" of housepit 49, 45-BN-53, McNary Reservoir. The saucer-shaped floor was cleared following the primary occupation level.

entrance of the horse into local Indian culture, a dating that has in so far as I am aware, been acceptable to workers in the region. This site is in country now assigned to the Walla Walla or Walula tribe by ethnographers.

Antelope:

Housepit 2, (trenched) from surface to 3.3 feet deep: 2 left distal tibiae, 1 right calcaneum, 1 distal metatarsal, 3 skull fragments, 2 sternebrae.

Housepit 59, (trenched) from surface to 1.0 foot deep: 2 astragali (right and left), 2 metatarsals, 2 teeth; from 1.0–2.0 feet: 2 right astragali, 2 left distal tibiae, 1 right distal humerus, 1 right scapula, 2 right proximal ulnae, 1 left calcaneum, 1 lower tooth; from 2.0–3.0 feet: 2 metatarsals (distal and proximal), 1 right distal tibia.

Housepit 78 (tested and trenched) 0–1.0 foot: no bones; 1.0–2.0 feet: 2 vertebrae (1 dorsal, 1 sacral), 1 jaw fragment, 1 distal metatarsal.

Housepit 87, 0–1.0 foot: no bones; 1.0–2.0 feet: 1 horn core, 3 teeth, 1 axis; from 2.0–3.0 feet: 1 maxilla, 2 distal tibiae; from 3.0–3.5 feet: 1 jaw, 2 distal tibiae, 1 radius.

Bison: no bones.

Horse: no bones.

Forty-eight antelope bones were found in the limited excavations; they are representative of most of the major parts of the skeleton. Well over half (twenty-nine) of the bones are appendicular; they are the bones that one would logically expect to come into the village with partly butchered meat. The assemblage is not at all suggestive of bones traded in or saved for future use in making artifacts. The results of the food quest, primarily, are present. Antelope bones formed 28 per cent of the mammalian bones found at FR-5; jackrabbit (*Lepus townsendii*) bones formed 46 per cent. The remaining bones were those of squirrel, salmon, beaver, and frog.

Potholes site. This site was excavated by a non-archaeologist in the 1920's. Material found was deposited in the Washington State Museum. Apparently only graves were sought. Presumably most of the unworked bones found were discarded. Historically, the site would be in Columbia tribal territory. Contact or trade objects were found in the graves; the site was thus of a late date.

Antelope: one piece, worked into a wedge, is possibly an antelope radius (Washington State Museum, catalog No. 9304).

Bison: no bones, or none saved.

Horse: no bones, or none saved.

45-GR-2. This is a rock shelter or cave site, as we have rather loosely used the term. It is about eight footpath miles southwest of the town of Grand Coulee in the basaltic west wall of the upper Grand Coulee, Grant County and thus is in the southern part of the Nespelem tribal range. An analysis of the archaeological aspects of the excavation has been published.[14] The site deposits were prehistoric in date.

Antelope: no bones.

Bison: from second 6-inch level from surface: 1 mandible, 1 tibia, 1 astragalus; at *ca.* 4.0 feet from surface: 1 horn; at 5.2 feet depth: 1 mandible, 1 hoof; at *ca.* 2.5 feet: 1 astragalus, 1 calcaneum.

Horse: no bones.

Four per cent of the mammalian bones of GR-2 were those of bison.

FIG. 3. Housepit 14, 35-UM-17, under excavation. The series of trenches yielded a series of profiles that enabled the archaeologists to visualize subterranean construction.

45-OK-10. This is a small, three-housepit site some twenty miles down the Columbia from the Grand Coulee Dam. One housepit was excavated; several tests were made. The housepit yielded trade goods. This site, like the others, has already been described.[3]

Antelope: no bones.

Bison: test pit 5, from 1.0–2.0 feet: 1 astragalus.

Horse: no bones.

Only 0.7 per cent of the bones were those of bison.

45-OK-5. A small, five-housepit site, 45-OK-5 is on the north bank of the Columbia River about twenty miles below the Grand Coulee Dam in Okanogan County. Two of the housepits were thoroughly trenched; test pits were dug. The site is within the modern Nespelem tribal range. Results of the excavation of OK-5 and other sites in the area, i.e., within the Bureau of Reclamation's Chief Joseph Reservoir floodline, have been published.[3] The time of occupation of the housepits excavated was prehistoric.

Antelope:

Housepit 1, (trenched) in central section in 2.0–2.5-foot level: 1 mandible (right half).

Bison:

Housepit 1, 1.0–2.0 feet from surface: 1 femur, 2 tibiae, 8 metapodials, 2 carpal or tarsal bones, 2 astragali, 1 calcaneum; depth 2.0–3.0 feet: 1 femur, 2 tibiae, 8 metapodials, 4 phalanges, 1 ungual phalanx, 1 carpal or tarsal bone; at 3.0–4.0 feet in depth: 1 tibia.

Housepit 3, 1.0–1.5 feet in depth: 1 scapula. Unlocalized buffalo bones from the site: 1 humerus, 1 femur, 3 metapodials.

Horse: no bones.

FIG. 4. The remains of a recent type, elongate, mat house under excavation. Housepit 59, site 45-BN-6. A wide central trench and a narrow cross trench dissected the deposit.

FIG. 5. Excavation in the basalt cave, 45-GR-2, near the Grand Coulee Dam. Preservation of bone was excellent here in spite of the coarse, rocky fill. Note the hard hats.

Bison from 4 per cent and antelope 0.01 per cent of the mammalian bones from this site.

45-OK-2. This is a housepit site (16 pits present) about fifteen miles below the Grand Coulee Dam. It is within Nespelem tribal territory. Seven housepits were tested or otherwise excavated during the 1950 season. Two of the pits were postcontact, and contained an abundance of trade goods. The others lacked European- or American-made items. The site had no doubt been used for a long period. A description of the excavation has already appeared.[3]

Antelope: no bones.

Bison:

Housepit 5, occupied during postcontact times, 0–1.0-foot level: 2 phalanges, 1 astragalus.

Horse: no bones.

Three per cent of the bones found were those of bison.

45-OK-11. This is also a small site, in keeping with the settlement pattern of the area. It is about thirty miles below the dam. The eight pits were divided into four-pit groups. Four of the housepits were trenched. This site, which is prehistoric, has already been reported upon.[3]

Antelope: no bones.

Bison:

Housepit 6, prehistoric (no contact material), 0–1.0 foot in depth: 1 metapodial; 0.8 per cent of the bones recovered.

45-OK-12. This site is about 1000 feet downstream from OK-11. Only three pits were found; one was tested and was found to contain only aboriginal material.[3]

Antelope: no bones.

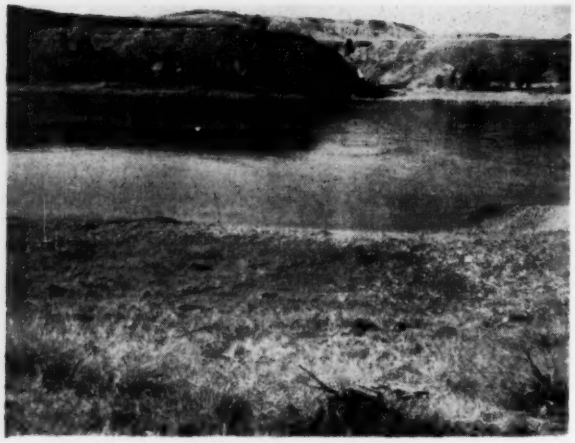

FIG. 6. Unexcavated housepit 6, site 45-OK-11, Chief Joseph Reservoir, Columbia River. The dark circular area in the mid-foreground outlines the shallow saucer-shaped pit over which a (presumably) wood and mat superstructure was erected.

Bison:

Housepit 2, 0–1.0 foot: 1 phalanx.

Horse: no bones.

Few bones came from this site; this phalanx represents 12 per cent of the amount found.

Upper Columbia 11. Collier *et al.*[15] found bones of bison four to five feet deep in the undisturbed midden of this prehistoric (no contact material) site.

45-LN-3. This cave or rock shelter site, in Lincoln County, Washington, is about seventeen air miles north northeast of Ritzville in the basalt cliffs above the north bank of Crab Creek. A ten-foot trench to the sterile soil was cut into the deposit. The site is wholly precontact.

Antelope: from deposit (thin midden), surface to 1.0 foot: 2 astragali, 15 metapodials (6 proximal, 9 distal), 1 sacrum, 9 phalanges, 7 lower teeth, 1 right distal humerus, 1 right jaw fragment, 3 maxillae (2 right, 1 left), 1 tooth, 3 distal metacarpels, 1 dorsal vertebra; from 1.0–2.0 feet: 1 tibia, 5 teeth, 2 phalanges, 4 metapodials (3 proximal, 1 distal); from 1.0–6.0 feet: 3 left maxillary fragments, 1 right jaw fragment, 22 deer or antelope bones (deer were also present at the site); from 2.0–3.0 feet: 1 right maxilla, 2 lower teeth, 3 metapodials (1 proximal, 2 distal), 1 distal humerus, 1 right astragalus, 2 phalanges, 1 right proximal ulna; from 2.0–6.0 feet: 1 left jaw fragment, 1 right premaxilla, 16 deer or antelope bones.

Bison: from deposit (thin midden), surface to 1.0 foot: 1 right radius, 1 upper tooth, 1 left jaw fragment, 1 left ilium, 5 vertebrae (3 dorsal, 2 lumbar), 9 carpal bones, 2 phalanges, 1 right proximal tibia, 2 sternebrae, 1 sacrum; from Room A, a superficial pocket: 1 distal humerus, 1 fetal h[u]merus, 1 dorsal vertebra, 1 sternebra, 1 carp[al] bone, 3 phalanges, 1 fetal metatarsal; from 1.[0–] 2.0 feet: 2 hyoids (1 right side, 1 left side); fro[m] 1.0–6.0 feet: 1 immature right pelvis, 1 cuboid, lower tooth, 2 phalanges; from 2.0–3.0 feet: 1 do[r]sal vertebra, 2 phalanges, 1 right proximal radius, carpal bones; from 2.0–6.0 feet: 4 phalanges, carpal bones, 1 immature distal tibia, 2 immatu[re] distal metapodials.

Horse: no bones.

Of the large number of bones (670) found [at] this site, about 11 per cent are those of antelop[e] and 8 per cent those of bison. The remainder a[re] largely from small game such as ground squirr[el] jackrabbit and cottontail, gophers and marmot[s]. The top foot of the deposit held almost half of th[e] antelope and bison bones. There is a marked in[-] crease in the amount of bones of both animals fro[m] the deeper levels to the surface; this is more regula[r] for the antelope than for the bison. The leve[l] removed here should have been six inches, rathe[r] than one foot, to secure a more sensitive record.

45-LN-1. This is a site similar to LN-3. It [is] approximately two hundred yards east of th[e] former and also is prehistoric. Although it appeare[d] to be the better site it yielded less.

Antelope: from deposit (thin midden), surfac[e] to 0.5 foot: 2 teeth, 1 phalanx; from 0.5–2.1 feet 1 tooth, 1 phalanx; from 2.1–3.9 feet: 1 tooth 1 phalanx.

Bison: from surface to 0.5 foot: 1 tooth; from 0.5–2.1 feet: 1 phalanx.

Horse: no bones.

Eight per cent of the bones from this site were antelope and 2 per cent were bison. The bones o[f] the antelope were rare but were evenly distributed

FIG. 7. Housepit 1, site 45-OK-1. Partly cleared, in process of mapping.

roughout the deposit; those of the bison were ithin the top two feet of this site.

45-DO-3. A cave in Douglas County, this site as found by survey in 1952. Surface collection nly: deer or antelope: 1 distal metapodial.

45-KL-18. This is a cave as is DO-3. Surface nds only: deer or antelope: 1 carpal bone. Sternerg[16] found modern bison bones associated with rtifacts at "Pine Creek."

Data from these last three sites are not included n the final tabulation or in the discussion.

Conclusions

When the finds of animal bones are plotted on map it becomes apparent that both of the wild orms have sufficient distribution so that their resence in the area cannot well be a point of rgument. True, FR-5 and BN-16 are not so far rom Oregon that hunting parties could not have arried antelope meat home from territory that is ow within that state. When one considers the hysiography and the hunting habits of the people, owever, this possibility becomes little less than remote. The antelope mandible at 45-OK-5 is probbly an import into that foothill-like region but it ertainly could not be taken to indicate trade with, r hunting parties to, Oregon. Also, the fact that ntelope was the second most important mammal t FR-5 (the most important was jackrabbit) indicates nothing more than local hunting. At nearby N-16, antelope was also important. As has been tated, bones from the sites BN-3, BN-15, DO-3, L-18, and Potholes were deer or antelope bones nd are thus dubious. Those at BN-3, a Late site (trade goods abundant), were across the river from orthern Oregon, an area where antelope are nown historically. The Lincoln County caves had a respectable quota of antelope.

Bison, with the exception of sites FR-5, BN-16, nd the Lincoln County caves, was the more imortant game animal. Like the antelope at FR-5, ufficient parts of the skeleton were generally presnt to indicate that the animal was hunted close to ome. Bones were fragmented for the marrow, vidence that they had not been carried great disances for other uses. It is well known that tribes f Washington and Oregon, from the Okanogan to he Nez Percé, made journeys in the latter half of he nineteenth century and possibly somewhat arlier to the country east of the Rockies to hunt ison. This hunt was often as much for purposes of pleasure, travel, and trade as for procuring meat. Loads of dried meat were, of course, brought home. The bones that we have found do not fit into this situation nor into a theory that they were selected

FIG. 8. Housepit 3, site 45-OK-4. Beginning of excavation.

as raw material for bone artifacts. In the sites bearing bison bones, deer (*Odocoileus*) was usually the most important mammal. This was doubly true in the north, in Okanogan County. It appears that bison, like antelope, were available to Indian hunters in both the north and the south. The quantities and proportions of bones suggest that these animals were, at least from time to time and place to place, more than casual visitors. Probably small bands and strays were neither unusual nor rare in both prehistoric and protohistoric or very early historic times in eastern Washington. The fetal and immature bones from 45-LN-3 indicate breeding in the area.

Table 1 presents some interesting information. Here the site occurrences have been given for the three mammals by lower and upper levels. It would not be of value here to present my reasons for assigning each find to an upper or lower level. With stratified sites such assignment is simple. However, stratified sites are rare in the Plateau; consequently, it has been necessary to split each site according to its relative depth, i.e., a site with a four-foot-deep deposit would, all other things being equal, be split into an upper level of the top two or two and one-half feet and a lower one of two or one and one-half feet. This is obviously arbitrary. The measure of a site's recency is of course the presence or absence of trade items such as glass beads, iron and copper. Horse bones, too, are a mark of recency and of course, as such, appear only in the Late sites in Table 1. This is not so much an aspect of reasoning in a circle as it is evidence of the control that the mammalogists have of their material. I should also add that no site has been judged "Late" solely on the presence of horse bones. The finds of trade items were primary evidence;

TABLE 1*

		Bison	Antelope	Horse
Late sites	Upper levels	4	1(?)†	2
	Lower levels	2	1(?)	1
Prehistoric sites	Upper levels	8	4	
	Lower levels	5	5	

* Potholes site, omitted. No data available as to depth of questionable antelope find.
† 1(?) is 45-BN-3, site 1 Fig. 1. Separate occurrences listed in columns.

the osteological reports came in later as interesting corroborative evidence.

I am not impressed by the fact that there are more finds of bison for the Prehistoric sites. There are four Late sites and eleven Prehistoric ones. It is true that more digging has been done on the Late sites, so that disparity of earth turned is far less than a 4 to 11 ratio. As mentioned before, the time is not yet ripe for a quantitative analysis here. What is important, in so far as bison are concerned, is that they have been present from wholly pre-contact times until well into the contact period.

Antelope, I am convinced, show a different picture. All antelope bones from Late sites are "deer or antelope" bones in poor condition. The certain finds are all from Prehistoric sites, 28 per cent antelope at FR-5. It would appear that the obvious interpretation is that antelope were present in prehistoric times, possibly as late as the 1600's, and that they then become nearly extinct in Washington. A few old-timers in the Pasco area (some eight miles from FR-5) recall antelope in the region in early days. Whether these men are thinking of herds in Oregon or in Washington is obscure. Ethnographers now in the field are finding that antelope were well known to the Indians of southern Washington. It is wholly possible that temporal depth on the ethnographic level can be found when both northern and southern tribes are well studied. Ray[17, 18] describes or lists antelope hunting for the Sanpoil and Nespelem, Wenatchi, of north central Washington, and the Klikitat, Tenino, Umatilla, and Kittitas of southern and central Washington. It is of interest that antelope and horse are never found together in spite of the fact that the horse (a late arrival in the area) finds are grouped in the south, nearest the present antelope range. Certainly the information that Dalquest[5] presents and that which has come from this study coincide. He sees the antelope as a mammal that should have ranged in the eastern part of the state; my study shows it as a recent habitant.

The data for the presence of bison and antelope in eastern Washington in prehistoric time and, in so far as the bison is concerned, in protohistoric and historic times, are sufficient. The questions raised by these data must remain unanswered, at least by an archaeologist, for the present. Digging will be done in the future in the area, and it may be that clarifying information will be forthcoming.

It is difficult to suggest reasons for the apparent abandonment of the region by the pronghorn, a mammal so suited to it. I can see no reason why the acceptance of the horse, particularly by the tribes of the southern Washington-northern Oregon areas, should have made life more difficult for antelope in the northern state than in Oregon. It must be that climatic changes were primary in displacing the antelope from the northern section of their range, if my data and interpretations are correct. Nothing less than a change in living conditions or a most virulent epidemic illness could adequately explain the situation, and the latter is a sort of last-refuge suggestion.

In his magnificent study of postglacial forest successions, Hansen[19] has presented evidence of a moist, cool, climatic pulsation beginning about 4000 years ago, and possibly tapering off at about the present time. Colder winters, deeper and longer-lasting snows, and an influx of northern predators —all of them aspects of such a climate in the region—might well have upset the balance that made the eastern part of Washington habitable for the antelope. Their next stand would have been in eastern Oregon, a still drier area than Washington, and a part of the antelope range to the present day.

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Books Reviewed In SCIENCE

October 2

Structure Reports for 1949, Vol. 11. A. J. C. Wilson, Gen. Ed. Utrecht: Oosthoek, 1952. (For the International Union of Crystallography.) 477 pp. Illus.
Reviewed by Karl Lark-Horovitz.

Astrophysics: The Atmosphere of the Sun and Stars. Lawrence H. Aller. New York: Ronald Press, 1953. 412 pp. Illus. $12.00.
Reviewed by D. ter Haar.

Synthetic Organic Chemistry. Romeo B. Wagner and Harry D. Zook. New York: Wiley; London: Chapman & Hall, 1953. 887 pp. $11.50.
Reviewed by Ralph L. Shriner.

October 9

New Zealand Pollen Studies: The Monocotyledons. Lucy M. Cranwell. Cambridge, Mass.: Harvard Univ. Press, 1953. (For the Auckland Institute and Museum.) 91 pp. Illus. + plates. $5.00; paper: $3.50.
Reviewed by F. R. Fosberg.

Differential and Integral Calculus. Philip Franklin. New York–London: McGraw-Hill, 1953. 641 pp. Illus. $6.00.
Reviewed by M. E. Shanks.

Industrial Wastes: Their Disposal and Treatment. Willem Rudolfs, Ed. New York: Reinhold, 1953. 497 pp. Illus. $9.50.
Reviewed by W. T. Read.

An Introduction to Statistical Science in Agriculture. D. J. Finney. Copenhagen: Ejnar Munksgaard; New York: Wiley, 1953. 179 pp. Illus. $3.75.
Reviewed by Gordon E. Dickerson.

Atlas of Medical Mycology. Emma Sadler Moss and Albert Louis McQuown. Baltimore: Williams & Wilkins, 1953. 245 pp. Illus. $8.00.
Reviewed by Russell J. Fields and Raymond A. Osbourn.

October 23

Modern Radiochemical Practice. G. B. Cook and J. F. Duncan. New York: Oxford Univ. Press, 1952. 407 pp. Illus. + plates. $8.50.
Reviewed by Richard M. Lemmon.

Chemical Process Machinery. 2nd ed. E. Raymond Riegel. New York: Reinhold, 1953. 735 pp. Illus. $12.50.
Reviewed by Ju Chin Chu.

Speech and Hearing in Communication. 2nd. ed. of *Speech and Hearing.* Bell Telephone Laboratories Series. Harvey Fletcher. New York–London: Van Nostrand, 1953. 461 pp. Illus. $9.75.
Reviewed by John Q. Stewart.

The Science of Color. Committee on Colorimetry of the Optical Society of America. New York: Crowell, 1953. 385 pp. Illus. + plates. $7.00.
Reviewed by A. Chapanis.

October 30

Phosphorus Metabolism: A Symposium on the Role of Phosphorus in the Metabolism of Plants and Animals, Vol. II. Sponsored by the McCollum-Pratt Institute of The Johns Hopkins University. William D. McElroy and Bentley Glass, Eds. Baltimore: Johns Hopkins Press, 1952. 930 pp. Illus. $11.00.
Reviewed by Mark H. Adams.

Sampling Technique. William G. Cochran. New York: Wiley; London: Chapman & Hall, 1953. 330 pp. Illus. $6.50.
Reviewed by Marvin Zelen.

BOOK REVIEWS

The New Force. Ralph E. Lapp. x + 238 pp. $3.00. Harper, New York. 1953.

IN this latter-day Smyth Report, Dr. Lapp presents, primarily for the lay reader, an account of the evolution and present status of atomic energy, as it relates to both war- and peace-time uses. Scientists who have not been closely associated with the developments he details will find that this volume serves as a nontechnical summary of and commentary on numerous newspaper reports and technical accounts, and thus performs a useful function.

In nontechnical language (and occasionally using oversimplifications which in a different context would subject him to criticism from his colleagues), the author traces the experimental steps leading to the discovery of fission and the war-time development of the first A-bombs. The tale he recites in his early chapters is much more than twicetold, but the "I was there" approach he uses, together with the journalistic style employed, makes the reading pleasant and painless, if not exciting.

Postwar developments are viewed from the vantage point of a participant in many of the developments, and numerous personalized comments and pertinent quotations shed new light on some of the happenings in the atomic energy field since VJ-day. The transition from Manhattan District days to the period of AEC activity is treated in some detail, and the growth and accomplishments of the Commission are given adequate space.

In the chapter he entitled "Destruction Unlimited," the author comments on the greatly increased efficiency and destructive power of post-Nagasaki A-bombs, and devotes an extensive section to a treatment of the principles underlying the H-bomb. A discussion of the attempts made thus far to reach international agreement on the control of atomic energy leads the author to conclude ". . . the real significance of releasing atomic energy is that war must be abolished from this earth."

Recent technical developments and trends are summarized in chapters dealing with battlefield A-weapons (such as the small A-bombs for tactical use) and atomic power. Possible peace-time benefits are dealt with in his discussions of both the varied uses of radioisotopes and the commercial development of atomic power.

In a strongly worded statement on "Secrecy and the Atom," the author deplores what he considers to be an overemphasis on security. He feels that current security measures result in keeping from the American people facts they need in order to evaluate properly the meaning of atomic energy in war and peace. He also discusses the difficulties these policies pose for American scientists as they strive to unravel further the mysteries of the nucleus. His arguments along these lines are generally convincing, but the author at times makes overstatements which weaken his case.

With relatively few reservations, this reviewer finds it possible to agree with a summarizing sentence in Stewart Alsop's foreword to the book: "In *The New Force,* . . . Dr. Lapp has been able to present the facts of atomic energy clearly, readably, and yet with complete scientific accuracy."

BOWEN C. DEES

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Teamwork in Research. George P. Bush and Lowell H. Hattery, Eds. xii + 191 pp. $4.00. American University Press, Washington, D. C. 1953.

IN the last ten years, research and development has become an important phase of big business; in fact, research and development has become big business on its own account. Although research and development had a place in industry before World War II, the real impetus toward increasing it came through military research in the years from 1940 to 1946. During this period many research men who were excellent scientists had a chance to try their skill as scientific administrators. Fortunately, a large percentage of them were successful, and those who were not could ordinarily hide their failures in the fog of changing objectives, loss of personnel, and unstable finances of this war period.

At the end of the war, a small group of these amateur research administrators got together and talked about their successes and failures. It was quite apparent that there was much to be learned from both. This led to a symposium or seminar on the administration of research on a national scale. One such group, starting in 1947, has held a meeting each year and has brought together research administrators from Government, industry, and the colleges. It is almost inevitable that similar symposia and conferences, both transient and permanent, will spring up here and there. Several colleges have instituted courses in this field, and the literature on research administration is becoming quite extensive. It seems that by now almost all facets of research administration have been discussed and thoroughly explored—costs, recruitment, training, inventiveness, patents, and publication policies have all been the subject of one or more extensive discussions.

This particular collection of papers is aimed at a discussion of "teamwork in research." No one denies the importance of such teamwork, and most of us will admit that the lone inventor and scientist is not as prevalent or as important in the total research picture as he used to be. Science is too broad and requires too wide a knowledge for a lone inventor to contribute. A team, contributing from many fields of science, is a much surer way of achieving success on large problems.

This book covers four phases of teamwork—organization, personnel factors, aids to teamwork, and case examples by some who have been only analysts of the

nation. What use either an experienced or prospective search director might make of this book is obscure, t one talk, by M. A. Tuve, clearly shows what makes r teamwork. This chapter, which is all too short, thfully reflects the enthusiasm, hard work, and de- ion to the job which makes a team a productive one. owever, how this is done or by what rules one ac- mplishes it is not set down in books. Baseball, like search, is big industry too. The Chicago Cubs alone erate on a budget of three million dollars per year. aseball too, like research, is played by teams, the in- iduals of which are experts in their jobs. It is my inion that the best way to play center field, as Ralph iner plays it, is to have some native talent and then ve as an understudy to Kiner, and not to read a book teamwork in baseball. Similarly, the best way for a ader to learn to encourage teamwork by his research oup is to watch how men like Tuve do it and then likewise.

ERIC A. WALKER

hool of Engineering
nnsylvania State College

e Road to Abundance. Jacob Rosin and Max East- man. vii + 166 pp. $3.50. McGraw-Hill, New York. 1953.

THIS book is a gospel of two freedoms made pos- sible by chemistry.

Freedom from food: someday we shall make fats and rbohydrates in the chemical factory, and satisfy our eds for proteins by eating synthetic amino acids or lankton or Chlorella algae grown in tanks. For "there nothing profoundly natural about our eating natural od. . . . The starch of the potato is meant by nature be a food reservoir for the potato plant, not the hu- an stomach; the milk of the cow is meant for calves. . . A balanced mixture of (synthetic) amino acids is more logical raw material for the natural synthesis our body proteins than the animal and vegetable roteins we eat." (p. 33.)

Freedom from the mine: abundant, cheap, energy om the sun will revolutionize our chemical processes nd allow us to extract traces from tons. The tons will e sea-water, low-grade ores, neglected raw materials, nd recovered industrial wastes. The traces will be gold, agnesium, bromine, uranium, nitrogenous fertilizers, ubber, titanium, and a host of new synthetics.

How shall we achieve these two freedoms? By a central authority backed by governmental funds (mo- ilizing) the entire industry, assembling America's best rains in an organized effort." (p. 92.) And what will hese two freedoms give us? The "eight-hour week or onth. Human effort may be absorbed in pure and cientific research and aesthetic creation, in a society ased on absolute abundance." (p. 108.)

It is unfortunate that the style is so studied as to ake the exciting subject matter seem dry indeed; that preaching their gospel the authors should lack hu- or, should speak cynically of the "pathetic efforts of chnological reactionaries to defend natural fibers" (p. 30), and should appear as defeatists in pleading their cause. Elsewise they might achieve more converts to their doctrine than, I fear, there will be.

There are some scientific errors: the critical step in getting magnesium from sea water is in precipitating filterable magnesium hydroxide (p. 71); scintillation of a single alpha particle is one of many chemical experiments involving less than a thousand molecules (p. 153); war was a consequence, not a cause, of the Haber process, first described in 1908 (p. 128).

But there is also a multitude of fascinating little facts that will excite the scientist: two-thirds of our energy from coal, oil, and gas is wasted into the air; three days of sunshine falling upon our earth gives us more energy than could be gotten from all the oil, coal, and timber on the earth; a one-acre algae farm could rival 100 acres of wheat; radioactive carbon-14 experiments show that the earliest agricultural settlement was 7000 years ago in Mexico, not in the Old World; and a single transcontinental telephone call utilizes 13,200 electronic tubes.

Although written in a pedantic style, the book has much original thought and a real message.

HUBERT N. ALYEA

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Digging Beyond the Tigris. Linda Braidwood. xii + 297 pp. Illus. + plates. $4.50. Schuman, New York, 1953.

EXCAVATIONS in Mesopotamia began about a hundred years ago, largely because of the western world's interest in the Scriptures. The feverish quest in such ruins as Nineveh, Khorsabad, and Nimrud, was primarily for reliefs and inscriptions shedding new light on the Bible.

At the turn of the century a broader humanistic approach began to pervade the Near Eastern excavator. His major concern was no longer Biblical relevance but the history and culture of the three high ancient civilizations: Sumerian, Babylonian, and Assyrian. At the same time he developed more trustworthy excavating techniques based on stratigraphy and architecture. Inscriptions were still more than welcome, but now all significant "finds" were carefully gathered and studied, particularly the lowly but indestructible potsherd. Even so, the stress was still on the literate cultures, and the prehistory tended to suffer from neglect.

In more recent years, largely due to the rise of anthropology as a full-fledged academic discipline, Mesopotamian archaeology is witnessing a considerable shift in temper and attitude. Interest is no longer concentrated on the elaborate city sites with their promise of temples, palaces, and inscriptions. Some archaeologists prefer to dig the ruins of the peasant villages which preceded the urban civilizations by many centuries, particularly those located in the out of the way highland districts of Northern Iraq. For there is reason to believe that this is the region where man's first radical economic revolutions took place, where the food-gatherer was transformed to a food-producer.

One of the more prominent pioneers in this recent trend is Robert Braidwood, of the University of Chicago, who combines a rich experience in Near Eastern archaeology with the fresh and fruitful anthropological approach. In 1950–51 he conducted excavations at Jarmo, a remote site in the Kurdish hills, which covers the ruins of the oldest known Mesopotamian farming village. *Digging Beyond the Tigris* is the story of this excavation.

The author of the book, however, is not the director, but his wife Linda, and its pages do not deal with the scientific results of the expedition except for one highly informative chapter near the end. The book is devoted primarily to a description of "life" on the dig, its laughter and its tears, its thrilling excitement and its dismal monotomy. The reporting is at times a bit too literal and obvious. Yet by the time the reader has turned the last page he will have participated vicariously in a rather novel, and refreshing, if far from comfortable way of life. What is even more important, he will be deeply moved, as I was, by the unquestioning and unswerving devotion to fundamental scholarship and pure research on the part of a small band of American scientists eager to help uncover the history of man's past—a not uncomforting phenomenon in this atomic age with its pressure for "salvation" rather than truth.

SAMUEL NOAH KRAMER

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Cacti and Succulents. G. Gilbert Green. 238 pp. Illus. $7.00. Pitman, London, New York. 1953.

CACTI and succulent plants will probably always be fascinating for those who grow plants and at the same time are attracted to the bizarre in plant form. Numerous books have been written upon the subject of growing succulents since they first became known horticulturally, which actually means since their discovery, for many of them have been made known to the scientific world by growers rather than by botanists. *Cacti and Succulents*, one of the latest of many similar works in several languages, is devoted in great part to sketchy descriptions of the plants, many of which are not available to his readers. His horticultural advice is mostly sound, and is applicable wherever the plants may be grown; however, the soil mixtures that he recommends are a bit coarse for the American climate, and keeping small pots dry all winter is not recommended in this climate. It is also questionable whether all of the plants he indicates as being suitable for window-sill culture are truly satisfactory for that purpose. The illustrations are rather pleasing, although some are too small to give the proper conception of the plant shown. The color pictures of the yellow-flowered cacti are not good; the yellows are much too pale.

The author does not show too thorough an understanding of scientific terminology in his use of the word family, for he all too frequently speaks of a genus as a family, and calls genera races. This type of confusion of terms is a common error of many horticulturists, and makes one wish they would better inform themsel
before they write upon such subjects. There are a
some other nomenclatorial errors, such as listing
same species under two different genera, the use of s
tribes as genera, and the use of some names that h
no botanical standing. His geography is not good w
he refers to the cactus tribe Opuntiae as "from Ameri
California to Guatemala," whereas members of the ge
Opuntia grow from Canada to the Straits of Magell
There are also other geographical blunders and numer
errors as to the color of flowers.

In spite of these and other errors which are disturbi
mostly to the specialist, the book will no doubt be
useful one for many amateurs who would like a qu
resume of the general field.

EDWARD J. ALEXAN
The New York Botanical Garden

Calculus. C. R. Wylie, Jr. x + 565 pp. Illus. $6.00. M
Graw-Hill, New York. 1953.

THIS text presupposes a course in analytic geom
try, covers the conventional elementary mater
of differential and integral calculus, and closes with
introductory chapter on differential equations. Exc
for the first two chapters, the material is conventiona
arranged; differentiation is studied extensively bef
any detailed material is presented on integration. Th
are numerous illustrative examples and exercises, ma
of which involve familiar applications.

The novel first chapter, on "The Calculus in P
spective," presents a clear intuitive account of the pr
lems of slope and area. Simple quantitative examp
and applications are discussed rather skillfully.

With this promise of ulterior significance, t
thoughtful student may be expected to take an acti
interest in the long (32 pages) and demanding sec
chapter on "Limits and Continuity." One misses h
the essential facts on absolute value and inequaliti
usually unfamiliar to students, without which even
modest ε-δ technique is impossible. Moreover, the de
nition given for "$f(x) \to \infty$" is really that for "$|f(x)$
$\to \infty$"; by the definition given, $n(-1)^n \to \infty$ as $n \to$
Finally, although the notion of continuity is clearly d
cussed and admirably illustrated, only algebraic prope
ties of continuous functions are listed. As a consequen
the attainment of extreme values is tacitly assumed
159), the "intermediate value property" is tacitly a
sumed (p. 173), and an essential statement really d
pending on uniform continuity is offered (foot of
161) with inadequate evidence. (If $z_{in} = i/n$ $(i = 1, \ldots$
$n)$, then with i fixed, $z_{in} \to 0$ as $n \to \infty$; but $Z_n = m$
$z_{in} = 1$ so that Z_n cannot approach zero.)

Minor criticisms for which argument stronger th
the reviewer's prejudice can be given, involve: Oc
sional use of the notation $\int_a^x f(x)\,dx$ instead of, e
$\int_a^x f(t)\,dt$; $\ln x$ instead of $\ln |x|$ as an antiderivative
x^{-1}; questionable symbolism, language, and equations
connection with the indefinite integral (pp. 184–5);
of technical terms not listed in the index (and presu

ly undefined)—e.g., "piecewise continuous" (p. 179), ounded" (p. 456); reference (p. 173) to an "aver- e" height of a function with a jump discontinuity fore such functions have been brought informally (p. 9) under the scope of the theory. The diagrams are nerally good.

Criticisms similar to the foregoing can be urged inst most calculus texts. The principal advantage of s text seems to be a pervading concern with the stu- nt's difficulties. The first chapter may turn out to be a nuine pedagogical contribution, and there are many luable details.

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ewart's Scientific Dictionary, 4th ed. Previously titled *National Paint Dictionary.* Jeffrey R. Stewart. 788 pp. $10.50 Stewart Research Laboratory, Alexandria, Va. 1953.

NO work more misnamed has come to the Editor's desk in years. This is the fourth edition of what as previously called the *National Paint Dictionary,* rtainly a far more appropriate title. No terms from the ological sciences are included in this "scientific dic- nary" at all. Its coverage of physical terms is suffi- ntly apparent from the absence of "protron," "neu- n," and "electron"; and its adequacy for general emistry is revealed by the absence of "valence" and the definition of "bond" as "the attachment at an rface between an adhesive and an adherent, or as a rb, it means to attach materials together by adhesives. he term is frequently used in the Adhesives Industry." Within the limits of the Paint Formulary, this is rhaps a useful reference work. It has a beautiful nding.

B. G.

gh Jungles and Low. Archie Carr. xvi + 226 pp. Illus. $4.50. University of Florida Press, Gainesville. 1953.

A professor at the University of Florida who spent several years at the Escuela Agrícola Panameri- na in Honduras, tells of his experiences during those ars in the surrounding country with enthusiasm and e keen awareness of a naturalist. The book has all rieties of subject matter in four major sections dealing th The Land, People In The Land, The Sweet Sea, nd Halls Of The Mountain Cow.

Anyone interested in additional information on jungle ildlife or the people of the tropics will find this book ry delightful. There is even an abundant sprinkling f common Spanish words used in Central America, rticularly those that apply to the ecology of the gion. One finds that they are compelled to keep re- rring to the adequate index so as to grasp the full nderstanding of the terms. After a while, this going ck and forth in the book ceases and one emerges ith a wealth of material.

With sympathetic understanding Archie Carr speaks isely, "that any naturalist worth his salt—and blessed with the opportunity—will go back day after day to the weeping woods or the rain-fed *selva* alike, and wander through the dim green light they share, conditioned by the prehuman look of the draped and festooned corridors to face any strange beast whatever, but not really disappointed if he should see nothing but the forest." So many expeditions have been made into the jungles expecting to see all manner of wildlife, but the initiated scientist knows better, "forest beasts may show almost unbelievable capacity for self-effacement."

There is an excellent plea for our wasting tropics and we can only hope that this is a step nearer in helping the Caribbean countries salvage their landscapes. The sections telling of the natives and the history of the country are very pleasant, but to us the most attractive parts of the book were the adventures in tapir country when he visited the Caribbean side of Nicaragua. The author kept a journal of his month-long expedition which makes fascinating reading for he encountered numerous adventures with wildlife in many surprising ways. Added to this are his experiences in camping and association with the natives.

The introductory material in the front of the book makes good reading and the several pages of photographs at the back add considerable interest and meaning.

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The Yields of a Crop. W. Lawrence Balls. xv + 144 pp. Illus. + plates + charts. 21s. Spon Ltd., London. 1953.

THIS book is an abridged account of varied experimental studies that were directed toward understanding and improving the yield of the cotton crop in Egypt. It concerns itself with the effects upon that yield of the reform and development of the irrigation system from 1882 onward.

In the first part of the book, the author discusses the essential features of the provision of water. He presents a strong presumption that the water table has risen throughout most of the Delta of the Nile as a consequence of the formation and raising of the Barrage pond south of that Delta and of the high-level canals derived therefrom, and shows evidence from limited experiments that this general rise has continued and is still continuing, with the result that the soils of the Delta are now shallower than ever.

The author then proceeds to discuss the results of experiments on the effect on yield of various physiological phenomena produced by temperature, assimilation, water shortage, soil composition, insect pests, soil volume, rising water table, and season. The interpretations given are used to assess the action of the various environmental factors on the yield since 1882. He shows that over 64 years no climatic changes could account for the broad outlines of the change in yield and that the relentless downward trend in that yield during half a century after eliminating the four major variants, namely, the cotton leaf worm, the pink boll-worm, nitrog-

enous fertilizers, and differential yield of varieties, is simply "an expression above ground of the rising water table below the ground."

The author concludes that, if deep soil is again available, the yield that was brought back by modern agricultural methods toward the neighborhood of the old peak value would be susceptible to improvement. This would require, however, the reconstruction of the irrigation system with a view to lowering the water table toward an ideal of three meters depth during the summer months and minimizing the rise provoked by the flood. Otherwise, "the basis of cotton yield in Egypt will fall slowly and steadily further."

The findings and conclusions of the author should be of much interest to agriculturists, especially in irrigated areas, and to research staffs in cotton manufacturing industries the world over; and the methods used in his study could be applied with modification to other crops.

In his presentation, the author makes use to the fullest extent of graphs and illustrations of which there are 52, including one large sheet that summarizes the history of the cotton crop in Egypt and of its measurable environmental factors from 1882 onward. A valuable bibliography on the yield of cotton, together with a supplementary list of publications by the author on other aspects of that crop, are also included at the end of the book.

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Social Behaviour in Animals. N. Tinbergen. xi + 150 pp. Illus. $2.50. Wiley, New York; Methuen, London. 1953.

THE gifted author states: "This book is not intended as an exhaustive review of facts. Its aim is rather the presentation of a new, truly biological approach to the phenomena of social behaviour." This reviewer wishes the claim had been for the presentation of a "needed" rather than a "new" approach. He remembers warmly the stimulus from reading the penetrating and basically similar, though factually more limited, writings of Charles O. Whitman and of William M. Wheeler. It is an honor to Tinbergen to mention him in association with these brilliant pioneers.

The topics discussed include: mating behaviour; family and group life; fighting; analysis of social cooperation; relations between different species; growth of, and evolutionary aspects of social organization; and selected hints for research in animal sociology.

The method of presentation is mainly by the use of well selected examples on the basis of which generalizations are given or implied. It is clearly stated that many conclusions are still tentative. Sundry of the examples have been used by the author in earlier summaries, such as his "An objectivistic study of the innate behaviour of animals" (1942), and his "The study of instinct" (1951). Here they are re-used in another tapestry of evidence and interpretation.

There is so much that is timely and good about this readable small volume, and the field so greatly need the thoughtful, provocative summaries such as Tinbergen characteristically gives, that I dislike to offer adverse criticism. There is one point, however, to which attention needs to be called.

I much appreciate the statement (p. 71) that "American literature contains many valuable contributions on the peck-order." The next sentence needs documentation: "In many of these papers, however, peck-order is claimed to be the only principle of social organization." I try to keep abreast with the work in this field and regret my recent preoccupation with other matters, which must have prevented my seeing all the available literature since this attitude regarding a form of social hierarchy had hitherto escaped me.

The book deserves a wide audience. It will be most useful to those who are not special students of animal sociality. However, there are stimulating ideas for all. Matters I found thought provoking include the use of the releaser concept to weave plant pollination by insects and birds into social behaviour (Chapt. VI). Batesian and Müllerian mimicry are made a part of the social field by using the same device. The brief discussion of homology and of convergence in behaviour patterns (Chapt. VIII) similarly caught my attention.

In conclusion, it is a pleasure to be able publically express my warm appreciation of Tinbergen and his work. It is perhaps not surprising that such a brilliant investigator appears not to hold himself always to recent journal literature in a thorough and scholarly fashion.

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Outlines of Structural Geology, 3rd ed. E. Sherbon Hill. xi + 182 pp. Illus. + plates. $3.00. Wiley, New York; Methuen, London. 1953.

THAT this concise book has served a useful purpose is evidenced by its recent revision to make the third edition, thirteen years after its first appearance. The author states that he has "aimed at presenting a brief yet reasonably complete and well-documented summary of structural geology, with special reference to those aspects of the subject with which the field geologist should be acquainted." The book has been modernized by the presentation of current concepts of tectonics, which in the nature of the case are yet controversial, in order to guide thought "along profitable lines of inquiry."

The book is a convenient, lucid digest for those who wish to become familiar with the structural features of rocks, although they may find some prior understanding of the principles of geology desirable. The chapter topics are: Non-diastrophic structures, rock deformation, major crustal structures, folds, faults, structures of igneous rocks, and petrofabric analysis. Abundant references to the literature are given in footnotes. The ample index makes the book more serviceable for reference use.

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ASSOCIATION AFFAIRS

AAAS SYMPOSIA AT THE BOSTON MEETING

SCIENTISTS well-established in their fields and young specialists alike have come to anticipate the AAAS symposia which have become an increasingly important aspect of the annual meetings of the Association. Characteristically, AAAS symposia explore relatively neglected areas of scientific inquiry or constitute up-to-date surveys of knowledge in particular fields. Such programs are significant and valuable because they focus attention upon critical areas, summarize the present status of current research, and provide positions from which to direct further research. Typically, these programs originate in the minds of the officers of the eighteen Sections and Subsections of the Association and are developed by them, either personally or by others deputized as program chairmen. Often the sectional symposia are concerned with interdisciplinary problems and are sponsored by two or more sections; participating societies also may collaborate. If the potential demand warrants it, the papers of such programs are gathered together and published by the Association as symposium volumes.

In recent years there has become well established the practice of arranging, for each annual meeting, several symposia of especially wide interest or timeliness. The responsibility for developing these general symposia, sponsored by the Association as a whole, rests upon the AAAS Symposium Committee, appointed each year by the president of the Association. Upon occasion, a proposed sectional program may be chosen to be developed as a general symposium; more commonly, the Symposium Committee, which represents a variety of scientific fields, plans and arranges these general sessions itself. The Committee may invoke the aid of consultants and appoint others to implement the general symposia.

This year the Symposium Committee consists of E. U. Condon, director of research, Corning Glass Works, and president, AAAS, (*chairman*); Frank A. Beach, professor of psychology, Yale University, and vice president for AAAS Section I; Bart J. Bok, associate director, Harvard College Observatory, and vice president for AAAS Section D; Charles D. Coryell, professor of chemistry, Massachusetts Institute of Technology; A. M. Gaudin, professor of mineral engineering, Massachusetts Institute of Technology; A. Baird Hastings, professor of biological chemistry, Harvard Medical School; Jerome C. Hunsaker, professor emeritus of aeronautical engineering, Massachusetts Institute of Technology; James R. Killian, Jr., president, Massachusetts Institute of Technology; Paul C. Mangelsdorf, director, Botanical Museum, Harvard University; Philip M. Morse, professor of physics, Massachusetts Institute of Technology; Alfred C. Redfield, associate director, Woods Hole Oceanographic Institution; Francis O. Schmitt, head, department of biology, Massachusetts Institute of Technology; Earl P. Stevenson, president, Arthur D. Little, Inc., and general chairman, Seventh Boston Meeting; George B. Wislocki, professor of anatomy, Harvard Medical School; and Raymond L. Taylor (*secretary*).

Of the general symposia at this 120th Meeting of the Association, "Species Which Feed Mankind" was suggested by Paul C. Mangelsdorf and "The Sea Frontier" was proposed originally by James B. Conant.

General Symposia

Species Which Feed Mankind. Arranged by Paul C. Mangelsdorf, director, Botanical Museum, Harvard University, and M. R. Irwin, professor of genetics, University of Wisconsin.

Part 1. Plant Species. 9:30 A.M., Sunday, Dec. 27; Paul Revere Hall, Mechanics Building.

Karl S. Quisenberry, assistant chief, Bureau of Plant Industry, U.S.D.A., *Presiding*

A. The World's Principal Food Plants. Karl S. Quisenberry.

B. America's Principal Food Species: *Zea mays*

1. Origin and Evolution of Maize. Paul C. Mangelsdorf.
2. The Nature of Variation in Maize. Edgar Anderson, associate director, Missouri Botanical Garden.
3. The Inflorescences of Maize. O. T. Bonnet, professor of plant genetics, University of Illinois.
4. Chromosomes, Cytoplasm, and Mutations in Maize. Marcus M. Rhoades, professor of botany, University of Illinois.

Part 2. Animal Species. 2:00 P.M., Sunday, Dec. 27; Paul Revere Hall, Mechanics Building.

Roy C. Newton, vice president, Swift & Company, *Presiding*

A. Agriculture versus Chemistry in the Nutrition of Man. Frederick J. Stare, professor of nutrition,

Harvard School of Public Health.

B. Animal Species Which Feed Mankind

1. The Role of Nutrition. L. A. Maynard, director, School of Nutrition, Cornell University.
2. The Role of Physiology. S. A. Asdell, professor of animal physiology, Cornell University.
3. The Role of Genetics. T. C. Byerly, director of animal and poultry research, Bureau of Animal Industry, U.S.D.A.

II. The Sea Frontier. Arranged by Alfred C. Redfield, associate director, Woods Hole Oceanographic Institution, and Jerome C. Hunsaker, professor emeritus of aeronautical engineering, Massachusetts Institute of Technology.

Part 1. 9:30 A.M., Tuesday, Dec. 29; Paul Revere Hall, Mechanics Building.

Henry B. Bigelow, curator of oceanography, Harvard University, *Presiding*

1. The Origin of Ocean Water. William W. Rubey, staff geologist, U.S. Geological Survey. (lantern, 30 min.)
2. Some Recent Results in Geology and Physical Geography of Ocean Basins. W. Maurice Ewing, professor of geology, Columbia University. (lantern, 30 min.)
3. The Sea as a Productive System. Alfred C. Redfield, Woods Hole Oceanographic Institution. (lantern, 30 min.)
4. Biological Resources of the Sea in Relation to Man. Lionel A. Walford, chief, Branch of Fishery Biology, U.S. Fish and Wildlife Service. (lantern, 30 min.)

Part 2. 2:00 P.M., Tuesday, Dec. 29; Paul Revere Hall, Mechanics Building.

Karl T. Compton, chairman of the Corporation, Massachusetts Institute of Technology, *Presiding*

1. The Edge of the Sea. Rachel L. Carson, Silver Spring, Maryland. (lantern, 30 min.)
2. The Continental Shelf. Henry C. Stetson, research oceanographer, Harvard University. (lantern, 30 min.)
3. Fresh Water from the Sea. Robert V. Kleinschmidt, consulting engineer, Boston. (lantern, 30 min.)
4. Shores and Their Sands. Frederick K. Morris, Air University and Massachusetts Institute of Technology. (lantern, 30 min.)
5. Making Ore Reserves. Antoine M. Gaudin, professor of mineral engineering, Massachusetts Institute of Technology. (lantern, 30 min.)

Sectional Symposia

B—Physics

Physics of the Upper Atmosphere (two sessions); arranged by G. G. Harvey.

Physics in Biology (two sessions); arranged by Richard S. Bear.

C—Chemistry

Comparative Nutrition Requirements of Animal Species (two sessions); arranged by Robert S. Harris and Frederick J. Stare.

Chemicals in Food (one session); arranged by Charles N. Frey.

Recent Advances in Food Technology (one session); arranged by Bernard E. Proctor.

Growth and Nutrition of Plants (one session); arranged by P. W. Zimmerman.

Chemistry of the Sea as Related to Food Problems (one session); arranged by Harold J. Humm.

D—Astronomy

Current Progress in Radio Astronomy (three sessions); arranged by Bart J. Bok.

Origin of Meteorites (three sessions); arranged by H. H. Uhlig and F. L. Whipple.

E—Geology and Geography

New England Geology (two sessions); arranged by Louis W. Currier.

Water for Industry (two sessions); arranged by Jack B. Graham and Meredith F. Burrill.

The Metropolis (one session); arranged by Victor Roterus.

G—Botanical Sciences

Second National Pollen Conference (three sessions); arranged by Stanley A. Cain.

The Uses of Large Scale Algal Cultures (two sessions); arranged by Barry Commoner.

H—Anthropology

Theoretical Models for the Study of Culture Change (one session); arranged by Evon Z. Vogt.

The Indians of New England: Their Archaeology and Ethnology (one session); arranged by Douglas S. Byers.

Nonhuman Primates and the Problems of Human Evolution (two sessions); arranged by James A. Gavan.

I—Psychology

Experimental Approaches to the Study of Brain Function (one session); arranged by Walter A. Rosenblith.

Comparative Studies of Social Behavior (one session); arranged by Burton S. Rosner.

Human Engineering and Information Theory (one session); arranged by Leonard C. Mead.

Sensory Processes (one session); arranged by Edwin B. Newman.

K—Social and Economic Sciences

The Scientist in American Society (two sessions); arranged by a committee of Section K, Conrad Taeuber, chairman, and a subcommittee of the Symposium Committee, Charles D. Coryell, chairman.

Regional Analysis (one session); arranged by Walter Isard.

The Economic State of New England (three sessions); arranged by Sumner H. Slichter and Walter Isard.

L—History and Philosophy of Science

Validation of Scientific Theories (one session); arranged by Philipp G. Frank.

Science and Its History: Three Currents of Interpretation (one session); arranged by Henry Guerlac.

Art and Science (one session); arranged by I. Bernard Cohen.

New Developments in Psychology of Thought (one session); arranged by J. S. Bruner.

Science and General Education (one session); arranged by Raymond J. Seeger.

M—Engineering

Communication Aids for the Blind (one session); arranged by Eugene F. Murphy.

Conservation of Human Resources: Highway Safety (two sessions); arranged by Irving P. Orens.

Nm—Medicine

Antimetabolites and Cancer (four sessions); arranged by Allan D. Bass and Cornelius P. Rhoads.

Nd—Dentistry

Recent Animal Experimentations in Caries Research (one session); arranged by Reidar F. Sognnaes.

Pathologic Disturbances of the Dental Pulp Resulting from Dental Operative Procedures (one session); arranged by Helmut A. Zander.

Periodontia (one session); arranged by Irving Glickman.

Np—Pharmacy

Professional Resources in Pharmacy in the United States (one session); arranged by George F. Archambault.

Accreditation of Hospitals: Its Effects on Pharmaceutical Services and Better Patient Care (one session); arranged by George F. Archambault.

O—Agriculture

Agronomic Problems of the Northeastern States (four sessions); arranged by Karl S. Quisenberry and C. E. Millar.

P—Industrial Science

Identification and Development of Senior Executives in American Industry: Contributions of Modern Science (two sessions); arranged by the Section Committee, Francis J. Curtis, chairman, and Allen T. Bonnell, secretary.

Q—Education

The Next Generation of Young Scientists and Their Science Teachers (one session); arranged by Morris Meister.

The Prediction of Child Development and Its Educational Implications (one session); arranged by J. R. Wittenborn.

Why Teachers Do and Do Not Use Films (one session); arranged by Mark A. May.

Visual Efficiency in Industry (two sessions); arranged by N. Franklin Stump.

Research on Higher Mental Processes (one session); arranged by Gerald V. Lannholm.

Symposia of the Participating Societies

Among the paper-reading sessions, seminars, and other events of the more than sixty participating societies and other organizations, are the following symposia:

American Society of Zoologists

Bioluminescence as a Tool in the Study of Cell Processes (one session); arranged by E. Newton Harvey.

Society of Systematic Zoology

The Phoronidea, Bryozoa and Entoprocta, and Brachiopoda: Their Status as Phyla and Their Relationships (one session); arranged by Waldo L. Schmitt.

Nomenclature: Results of the Sessions at the Copenhagen Congress (one session); arranged by R. E. Blackwelder and J. A. Peters.

The Subspecies versus the Cline: Their Biological and Nomenclatural Significance (one session); arranged by J. A. Peters.

American Society of Human Genetics *et al.*

Human Genetics and Medical Education (one session); arranged by Madge T. Macklin.

Genetic Factors Affecting Intelligence (one session); arranged by Frederick Osborn.

Genetics and the Races of Man (one session); arranged by William C. Boyd.

American Society of Naturalists and **Genetics Society of America**

Some Biological Effects of Radiation from Nuclear Detonations (one session); arranged by Alexander Hollaender.

National Academy of Economics and Political Science

Scientific Research and National Security (one session); arranged by Amos E. Taylor.

Society for the Advancement of Criminology

A Scientific Approach to the Problem of Delinquency (one session); arranged by Donal E. J. MacNamara.

American Association of Hospital Consultants

The Research Function of the Hospital (one session); arranged by E. M. Bluestone.

American Book Publishers Council, American Textbook Publishers Institute, and **AAAS**

Transmission of Ideas (two sessions); arranged by William E. Spaulding, John A. Behnke, and Richard H. Thornton.

Summary of Participating Organizations

With sessions of their own

AAAS Committee for Social Physics

AAAS Cooperative Committee on the Teaching of Science and Mathematics

Academy Conference

Alpha Chi Sigma

Alpha Epsilon Delta

American Academy of Forensic Sciences

American Association of Hospital Consultants

American Book Publishers Council
American Geophysical Union
American Industrial Hygiene Association
American Meteorological Society
American Nature Study Society
American Psychiatric Association
American Society of Human Genetics
American Society of Naturalists
American Society of Zoologists
Beta Beta Beta
Conference on Scientific Editorial Problems II
Conference on Scientific Manpower III
Genetics Society of America
Herpetologists League
History of Science Society
Honor Society of Phi Kappa Phi
Massachusetts Zoological Society
National Academy of Economics and Political Science
National Association of Biology Teachers
National Association of Science Writers
National Geographic Society
National Science Teachers Association
National Speleological Society
Philosophy of Science Association
Pi Gamma Mu
Scientific Research Society of America
Sigma Pi Sigma
Society for the Advancement of Criminology
Society for the Study of Evolution
Society of Exploration Geophysicists
Society of Systematic Zoology
Society of the Sigma Xi
United Chapters of Phi Beta Kappa

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American Society of Hospital Pharmacists
American Society of Plant Physiologists, New England Section
American Textbook Publishers Institute
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National Planning Association, New England Committee
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Scientific Manpower Commission

RAYMOND L. TAYLOR
Associate Administrative Secretary, AAAS